Malnourished children: An economic approach to the causes and consequences in rural Thailand

Sirilaksana Chutikul

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ABSTRACT This study undertakes an economic analysis of the causes and consequences of malnutrition among young children in a rural setting. Parents are viewed as productive agents who make interrelated decisions regarding their family size, labor force participation, expenditures, and intrahousehold distribution of resources in the face of constraints imposed by their resource limitations and a given "production technology."

The study utilizes data on preschool and school-age children obtained from a village-level survey in Northeastern Thailand and finds a familiar pattern of low income, high fertility, low nutrient intake and poor nutritional status and health. One finding, however—that mother's work in the formal labor market is detrimental to child nutrition—is unexpected and has important implications for policies designed to augment income through formal-sector job creation. The analysis also reveals that malnutrition and high fertility have adverse effects on the mental ability of the school-age children in the sample. By controlling for the environmental effects on intellectual development, the study offers some evidence to support the still-debatable contention that malnutrition has a direct, independent link to poor mental ability.

THE PROBLEM OF MALNUTRITION

During the past two decades economic growth has been achieved in many developing nations on an unprecedented scale. Gross national product (GNP) has increased at an average rate of some 5 to 8 percent per annum, and a high level of affluence has been attained in the capital cities. Yet, in the midst of growth and modernization, a large proportion of the population in these countries still lacks what the World Bank calls the "basic needs," consisting of sanitary housing, adequate clothing and food, and opportunities for learning. Realization that improvement in the quality of life should be the ultimate goal of development has led planners and policymakers to shift their attention from the pursuit of economic growth per se to concern over equity and distribution.

The case for this new approach can be made from another perspective. Any development scheme that overlooks the fundamental needs of the populace can at best be likened to an impressive superstructure built on shifting sand. The process of economic change is itself dependent upon the development of the country's human resources, and, as several studies testify, qualitative improvements in a nation's human capital form an integral part of economic growth (see, for example, Denison 1967; Jorgensen and Griliches 1967).

Malnutrition in childhood, and the morbidity it causes, can be seen as one of the most serious obstacles to the full development of a country's resource potential because of its pervasiveness. The problem is particularly severe in developing countries plagued with rapid population growth and

glaring inequalities of income and educational opportunities. Developing countries typically have a high proportion of the population in the youngest age groups, and it is known from medical studies that infants and children up to 5 or 6 years of age are among those most vulnerable to the ravages of malnutrition. UNICEF figures reveal malnutrition in combination with infectious disease to be the most important cause of child mortality in developing countries (UNICEF 1978). Berg (1973:4) notes that 57 percent of the deaths occurring to children in Latin America between ages 1 and 4 can be traced to malnutrition.

Types of malnutrition

Malnutrition manifests itself in various ways. First, *undernutrition* occurs when the general level of bodily intake is inadequate. (The problems of determining adequacy of intake are discussed in Appendix A.) *Protein–calorie malnutrition* (PCM) is the term used to describe dietary deficiencies in both protein and calories. Although the distinction is no longer as clear as it was once thought to be, the condition is called *marasmus* if the deficiencies are largely in calories and *kwashiokor* if they are largely in protein. Second, the lack of essential nutrients in the diet may give rise to *deficiency* diseases. Pellagra, scurvy, rickets, and anemia are among the diseases caused by deficiencies in certain vitamins and minerals.[1] Another kind of nutritional problem occurs when the ability to digest food and absorb nutrients is impaired by genetically or environmentally induced illness. Such illness results in *secondary malnutrition*. Finally, *overnutrition* results when too many calories or excess amounts of particular nutrients are consumed. Although this last type of malnutrition may be seen as a disease of affluence, giving rise to such conditions as obesity, that is not necessarily the case. For example, overconsumption of sugar or starch may be associated with poverty or inadequate knowledge of nutritional requirements, especially at times of cultural or environmental change.

Protein–calorie malnutrition in young children—the focus of this paper—is the form of malnutrition, or undernutrition, commonly encountered in developing countries and is most prevalent among the young. Generally-accepted standards exist for measuring PCM in children, making the task of defining this form of malnutrition more tractable. Malnutrition may be likened to insanity: difficult to define, yet obvious in its extreme state, so that its measurement is imprecise in in-between cases. For young

1. The causes of the deficiency may be complex. For example, anemia can result from an iron-deficient diet or from other causes such as parasitic infection, which may be complicated by low iron intake or by the intake of substances that lead to excessive iron excretion.

children, however, some degree of precision has been achieved and standard measures are widely advocated by nutritionists. Of all the types of malnutrition, PCM is likely to be the most closely related to parental decisions—for example, decisions about desired family size and the allocation of family resources. The larger the family, the more thinly resources have to be allocated among family members, and this is likely to be related more to the incidence of PCM than to other kinds of nutritional disorders. In contrast to PCM, other forms of malnutrition are specific deficiencies (or excesses), which in developing countries usually stem from the unavailability of particular nutrients in certain geographical locations. For example, goiter, a disease caused by lack of iodine, is common among inland peoples because iodine is found mainly in seafood. These specific deficiencies can be compensated for by technological means, such as fortifying certain foods, because their causes are known. PCM, however, may require a more complex set of solutions involving behavioral changes at the individual or family level, thus warranting closer investigation. The incidence of PCM is fundamentally an economic problem because it reflects inadequacies in overall food consumption. It is therefore related to the broader economic problems of resource availability, efficient utilization, and optimal distribution.

The effects of protein–calorie malnutrition

PCM affects the growth and development of children in three important ways.

First, physical growth may be permanently retarded by malnutrition in infancy and childhood. Early childhood is the period of highest growth, and inadequate energy or protein intake prevents the creation of new tissues. When the body does not receive enough calories, any protein intake will be used for energy purposes rather than for body-building (Whitney and Hamilton 1977). This results in physical retardation and stunting, which are hindrances to task performance. Productivity loss can be serious if malnutrition is widespread.

The second way in which PCM affects children's development is that it leads to high susceptibility to disease. It weakens the body and lowers resistance to infection, thus further inhibiting productive ability.

PCM in childhood may also impair the mental skills that are crucial for basic learning. Whether the effects of such afflictions are reversible, however, remains debatable. Selowsky and Taylor (1973) present evidence that malnutrition in the first year of life can have irreversible adverse effects on mental development even if nutrition later becomes adequate. Johnston and Clark (1979) argue, however, that recovery from mild to moderate degrees of malnutrition is usually possible. Although some tests for per-

manent brain damage, based on laboratory experiments with animals, suggest that malnourished animals can be rehabilitated by subsequent feeding (Levitsky 1976), the dangers of making inferences about humans from animal experiments are well known.

It is difficult to establish a causal relationship between malnutrition and mental retardation because malnourishment and the lack of environmental stimulation have similar effects on mental ability. Malnutrition rarely occurs in isolation. It is usually encountered in a poverty-stricken, overcrowded environment that stifles responsiveness to intellectual stimuli. Nevertheless, overwhelming evidence indicates that malnutrition and poor mental development are closely related, even though the actual causal mechanism is unclear (Cravioto and de Licardie 1973). Apart from humanitarian concerns, the effects of malnutrition on the brain have important implications for future economic productivity, since the effectiveness of skill training hinges upon the ability to learn.

Governments of many countries have introduced various measures designed to alleviate malnutrition. Extensive feeding and demonstration programs, fortification of food items, and development of high-protein foods have all been considered as solutions to the problem. But malnutrition itself has yet to be clearly understood and the causes and effects determined.

The task of ascertaining the causes of malnutrition can be approached from a macro level by determining the role of regional price differentials and the system of food distribution in a country. It can also be viewed from a micro perspective by investigating household behavior. Here attention is focused on rural households and the microlevel behavioral factors and resource constraints that can lead to malnutrition among rural children. In addition, the effects of malnourishment on the ability to learn are explored.

THAILAND AS A STUDY AREA

Thailand has long been a food exporter, and yet many groups of people in various parts of the country suffer from illnesses caused by inadequate diets. Thailand's nutrition problem is typical of the Southeast Asian region. The diet consists mainly of rice, and mild to moderate protein-calorie malnutrition is common. Pockets of malnutrition exist in both rural and urban areas where conditions are particularly severe (Stoecker 1979). A recent survey by the Ministry of Public Health, Nutrition Division (1982), of preschool children throughout the country (excluding Bangkok) found that 55 percent of the sample were malnourished. The problem is most pressing in Northeastern Thailand, where more than 35 percent of the country's estimated 50 million people reside. Its land is the least fertile, and its inhabitants have the lowest per capita income in the country. Because of political

priorities, the inherent unproductiveness of the soil, and the generally low bargaining strength of the local people, Northeastern Thailand has until recently benefited the least from rural development programs.

One ready, if rough, indicator of regional imbalance is the pattern in which irrigation spread in the country from 1961 to 1976 (Table 1). The percentage of irrigated land in the Central region increased from 38 percent in 1961 to 83 percent in 1976. In the South, where rainfall is on the whole sufficient and timely for agricultural purposes, the irrigated areas increased from 7 to 25 percent during that period. The low, stable percentages of irrigated land in the Northeastern region (around 5 percent) stand out in marked contrast to those of the other regions.

Another indicator of regional imbalance is the distribution of income. Per capita gross regional product (GRP) in the Northeast was only just over 14 percent of the corresponding figure for Bangkok by 1983 (Table 2).

Northeastern Thailand also ranks lowest in health statistics (Table 3). In Bangkok one physician serves an average of 1,230 people, while in the Northeast the corresponding figure is 29,348. The figures in Table 3 refer to government-provided services only. If private facilities were included, the imbalance would be even more pronounced because of the high concentration of private services and medical personnel in Bangkok and its environs. In 1982, 46 private hospitals out of a total of 155 were situated in Bangkok, serving only an estimated one-tenth of the country's population. And out of the total of 7,296 private hospital beds, as many as 3,727 were in Bangkok alone (Chutikul 1983:table 15).

A study by Krongkaew (1979) of health services and food expenditure estimates that malnutrition is most prevalent in the Northeastern region. Krongkaew converted the estimated minimum nutritional requirement into a typical food basket and computed its cost. Actual expenditure below this

Table 1. Irrigated areas as a percentage of cultivated areas of all types, by region: Thailand, 1961-76

Region	1961	1963	1965	1969	1972	1974	1976
Central	38	67	77	76	82	84	83
West	32	36	35	33	46	60	66
East	42	44	44	41	43	45	49
South	7	9	10	10	14	15	25
North	8	7	9	12	16	17	19
Northeast	5	5	6	5	6	6	5
Whole country	17	21	23	21	25	27	26

Source: Royal Irrigation Department, Ministry of Agriculture and Cooperatives (1979).

Table 2. Gross regional product at constant 1972 prices: Thailand, 1978–83 (million baht)

Region	1978	1979	1980	1981	1982	1983
Bangkok	16,567	18,153	18,687	18,631	18,845	19,611
Central[a]	6,171	6,738	7,010	8,242	8,439	9,337
West	8,130	7,516	7,885	8,424	9,281	9,145
East	11,040	10,402	11,061	11,715	11,478	11,954
South	5,308	5,467	5,267	5,400	5,383	5,490
North	4,048	4,077	4,107	4,397	4,400	4,504
Northeast	2,366	2,511	2,671	2,652	2,735	2,792
Whole country	5,873	6,092	6,304	6,554	6,682	6,931

Source: NESDB (1985).

Note: In 1983 1 baht was equivalent to US$0.037.

a. Excluding Bangkok.

minimum cost by any household was then taken to indicate the presence of malnutrition. From this simple comparison he obtained an estimate of the proportion of the Thai population that suffered from nutritional inadequacy in 1975. He estimated the extent of malnutrition at 31 percent for the whole country and at 42 percent for the Northeastern region, again the highest percentage of any region (Table 4).

Malnutrition among preschool children is also highest in the Northeast, with 59 percent of those surveyed by the Ministry of Public Health

Table 3. Health service and facilities, by region: Thailand, 1982

Region	No. of persons per hospital bed	No. of persons per district hospital or health center[a]	No. of persons per physician	Total population
Bangkok	365	—	1,230	5,120,000
Central[b]	479	119,481	12,680	9,678,000
North	934	134,959	12,942	9,987,000
South	727	160,222	14,643	5,768,000
Northeast	1,427	173,677	29,348	16,673,000
Whole country	732	163,526	7,221	47,219,000

Sources: MOPH, Provincial Hospital Department (1982); MOPH, Health Planning Division (1982); MOPH, Health Statistics Division (1984); NESDB (1980); Chutikul (1983).

a. District hospitals and health centers are located outside Bangkok.

b. Excluding Bangkok.

Table 4. Minimum nutritionally adequate food expenditure per household, actual food expenditure, and the presumed extent of malnutrition, by region: Thailand, 1975 (in baht)

Region	Minimum recommended expenditure on food	Actual expenditure on food	% of deficiency or malnutrition
Bangkok	1,499	1,345 (5.7)	10
Central	1,259	1,032 (5.2)	18
North	1,240	854 (5.1)	29
South	1,245	901 (5.3)	28
Northeast	1,403	813 (5.9)	42
Whole country	1,335	924 (5.5)	31

Source: Krongkaew (1979:table II-8).

Notes: In 1975 1 baht was equivalent to US$0.05. Numbers in parentheses are average household size.

in 1980 found to be malnourished (Table 5). Even though severe cases of malnutrition are rare, more than half of the preschoolers in Thailand are inadequately fed.

Medical specialists in Thailand have long been concerned with the problem of malnutrition and have begun to estimate caloric requirements and to gather information on malnourished children (Khanjanasthiti and Wray 1975; Khanjanasthiti 1977; Valyasevi 1977; Chavalittamrong and Vathanakanon 1978; NaBangxang and Tawichasri 1978). The causes of mal-

Table 5. Percentage distribution of preschool children, by nutritional status: Thailand, 1980

Region	%, by degree of malnutrition				Sample size
	Normal	First (mild)	Second (moderate)	Third (severe)	
Central	59	31	9	2	65,334
North	46	37	14	3	61,016
South	53	34	11	2	59,483
Northeast	41	42	15	2	290,648
Whole country (excluding Bangkok)	45	39	14	2	473,481

Source: MOPH, Nutrition Division (1982).

Note: Percentages may not sum to 100 because of rounding.

nutrition have received less attention, however, and analyses of social and economic factors have yet to proceed beyond the description of data. The pervasiveness of malnutrition and the existence of regional imbalance reaffirm the importance of determining the causes and consequences of the problem and its possible remedies.

STUDY OBJECTIVES AND OVERVIEW OF THE FINDINGS

This study analyzes the causes of malnutrition in rural Thailand, focusing on protein-calorie malnutrition in children, and traces the link between health and nutrition in the family and the acquisition of human capital, recognizing the interdependencies between children's nutritional status and health, parental fertility behavior, child mortality, allocation of parental time, and subsequent learning ability. (For details of the family decision-making model, see Chutikul 1982.) Nutrition is treated as a particular dimension of child quality, which is both "consumed" and "produced" by the household. A household produces children and determines their quality by the inputs of time and purchased goods, subject to the "production technology" that it possesses. Within this economic framework, the study analyses the pattern of parental behavior that affects food consumption and the nutritional intake of their children in the face of constraints imposed by limited resources and their production technology. It also ascertains the effects of nutritional status on learning.

The picture that emerges from the study is of a vicious circle of low income, high fertility, low nutrient intake, poor nutritional status, and poor health, leading possibly to impaired mental development and to future low income. Low income encourages childbearing because parents are dependent on their children as productive assets. Farm families with low incomes are particularly prone to have a large number of children. High fertility, however, means high sibling competition for resources at an early age when adequate nutrient intake is essential for normal physical and mental development. The situation is aggravated if the mother works outside the home for the nutritional status of her children invariably deteriorates. High fertility has a secondary effect in that younger children in large families do not perform as well as other children in school. If these children are also malnourished, their physical and mental risk is even greater. By controlling for environmental factors, the current study offers some evidence to support the still-debatable contention that malnutrition has a direct, independent link to poor mental ability. It also supports the results of previous studies that have stressed the importance of nutritional knowledge in ensuring the proper feeding of young children. The effect of parental behavior on children's well-being tends to outweigh that of physiological characteristics represented by pregnancy wastage and close birth spacing.

In fact, the data presented here suggest that a health-induced state of malnourishment transmitted from mother to child can be overcome by proper nurture and care. The presence of the mother in the home (rather than away from the home in formal-sector employment) is the single most important factor that augments the nutritional status of her children.

SAMPLE AND MEASURES USED

The data for the study were obtained from a survey conducted in the province of Ubon Rachathani in Northeastern Thailand in 1979. The population sampled consisted of children less than 7 years old who were living with both their biological parents. If a child's mother had experienced more than one marriage, siblings from previous marriages were excluded from the analysis of effects on the child's well-being but included in the mother's pregnancy history.

Twelve villages were surveyed, selected on the basis of their perceived economic characteristics, so that the whole range of high- to low-income groups would be more or less equally represented. Since it was a purposive survey of families with young children that exhibited "sufficient" variation in their economic characteristics, the sample was not intended to be representative of the total population. The probability of selecting a household was not necessarily proportional to the population size of each village, since households without young children were automatically excluded. Each village contained about 300 to 500 households, and approximately 10 percent of all households in each village were included.

Because childbearing and childfeeding information was sought, detailed information on household characteristics was obtained from the mothers. The pretests in which both mother and father were separately interviewed revealed that mothers could answer all the factual questions about household assets, income earning activities, farm size, costs, and so on just as accurately as could the fathers. Husbands' and wives' preferences regarding family size were also very similar, with a simple correlation of 0.89.

The survey gathered information about the health and nutrition of individual children. If the children had older siblings between 7 and 13 years of age who were attending primary school, information on those children, notably on their nutritional status and school grades, was collected from their schools.[2]

2. About five years before the survey, four of the twelve villages selected had either been the site of, or had contact with, health programs for as long as eighteen months. The programs were directed mainly at treating anemia and bladder diseases. In the anemia program pregnant women were given iron compounds to supplement their diets. The bladder disease project was conducted in nearby (nonsample) villages and provided some contact with proper health and childcare. Thus villages were classified

Details of the questionnaire design are contained in Appendix B. In total, data were collected on 1,006 preschool children and 410 primary school children from 582 households.

Nutritional adequacy was assessed by means of input measure—that is, a measure of food consumed by members of the houshold—and an outcome measure using anthropometric methods.

Nutritional input, or consumption by household members, was measured by the nutrient content of their food and by food expenditure per adult equivalent, valued at prices prevailing at the time of survey. The average quantity of food consumed by the family over the year was determined. (See Appendix B for details.) The twenty-four-hour recall method was not used because it fails to allow for day-to-day variation or seasonal differences and therefore could lead to large biases (unless repeated over the year and supplemented by extensive monitoring). A more meaningful method of approximating consumption, and in what quantities, was to have respondents report how often they consumed specific foods, although this method also resulted in some inaccuracy.

Individual nutritional intake was estimated as an average based on the family's consumption because differences among family members are difficult to determine where mealtimes are irregular and food is taken from several common bowls. But to refine the measure, different weights were assigned to family members according to their age and sex, adult males being assigned the greatest weight and women and children counting only fractionally. The weights used were adapted from the Amsterdam scale used by Stone (1954) because they are based on nutritional requirements:[3]

Age group	Weights for males	Weights for females
Under 6	0.35	0.35
6–14	0.52	0.52
14–18	0.98	0.90
18–45	1.00	0.90
45+	0.90	0.90

by the extent of their "program contact": being a program site, having had some contact with health programs, and having had no contact at all. Villages with at least some program contact were expected to have healthier children than other villages. The study failed, however, to uncover any appreciable difference in the health status of children merely on the basis of where they lived, but breastfeeding practices appear to have been affected.

3. A weakness of the Amsterdam scale is that it is not sufficiently refined. For example, it takes no account of the nutritional needs of women during pregnancy or lactation, or the needs of the chronically ill. Nevertheless, the distortion is believed to be small because only a small number of people fall into these categories.

Intake per adult equivalent so obtained was then analyzed according to its nutrient content and imputed purchase value.

The nutrients identified for the analysis were protein, calories, calcium, vitamin A, vitamin B1, vitamin B2, niacin, and vitamin C. Standard conversion tables were used to determine the nutrient content of the foods consumed. The nutritive value of each food group consumed was ascertained, summed up, and calculated in terms of adult equivalents. The intake was then normalized using recommended Thai standards.

Nutritional output, or status, refers to the extent to which food is absorbed and utilized in the body. It can be ascertained by clinical, biochemical, and anthropometric methods. This study uses anthropometric measures—that is, measures of the body's size and proportion, which indicate bodily growth. Such growth is considered to be "the severest test of nutritional sufficiency" (Garn 1966). Anthropometric measures are usually used to assess the degree of protein–calorie malnutrition, and because they are measures of overall sufficiency, they are often considered the most relevant indicators for the proper design of corrective policies. They include measurement of weight, height, head circumference, and skinfolds. Anthropometric measurements are particularly pertinent when the subjects being studied are children, being a more sensitive indicator of nutritional status in children than in adults. The measures used are: (1) the child's weight as a percentage of the reference weight for children of that age and sex, (2) the child's height as a percentage of the reference height for children of that age and sex, and (3) the child's weight–height ratio as a percentage of the reference weight–height ratio for children of that age and sex.

Gomez et al. (1955) established a method of classifying anthropometric measurements whereby the nutritional status of children can be identified. Modifications of their criteria are used in this study, based on the recommendations of Thai pediatricians (Kasemsant 1977). The standards for classifying children on the basis of each measure are presented in the Exhibit.

Nutritionists believe that, particularly during childhood, nutritional factors outweigh genetic influences in determining growth, so that anthropometric scores are reliable indicators of nutritional sufficiency. Each measure reflects a different dimension of nutritional status, so that even though they are cross-sectional measures, they can be used to infer nutrition patterns over time (Seonane and Latham 1971). Acute short-term malnutrition is indicated by low weight for age and low weight for height but normal height for age. Since height is a better measure than weight for assessing protein–calorie malnutrition over an extended time period, normal height suggests recency of deficiencies. Past chronic malnutrition, in contrast, is indicated

Exhibit. Standards for anthropometric measurement of children's nutritional status

Weight for age	
Normal +	over 100% of the reference weight for age
Normal -	90–100% of the reference weight for age
First-degree malnutrition	75–89% of the reference weight for age
Second-degree malnutrition	60–74% of the reference weight for age
Third-degree malnutrition	below 60% of the reference weight for age
Height for age	
Normal +	over 100% of the reference height for age
Normal -	95–100% of the reference height for age
First-degree malnutrition	90–94% of the reference height for age
Second-degree malnutrition	85–89% of the reference height for age
Third-degree malnutrition	below 85% of the reference height for age
Weight for height	
Normal +	over 100% of the reference weight for height
Normal -	90–100% of the reference weight for height
First-degree malnutrition	75–89% of the reference weight for height
Second-degree malnutrition	60–74% of the reference weight for height
Third-degree malnutrition	below 60% of the reference weight for height

by low weight for age and low height for age but normal weight for height. Persisting malnutrition is indicated by low percentages on all three indexes.

MODEL AND HYPOTHESES

A child's nutritional status reflects the combined effects of many factors, including nutrient intake, health, physiological characteristics, and behavioral factors governed by parental preferences. In this study, I consider the family to be a cohesive unit in which parents make decisions that simultaneously affect their fertility, labor force participation, and children's health, nutritional status, and survival. According to the economic model I have chosen, four "household commodities"—child nutrition, child health, child deaths (a negative commodity), and births are "produced" in the home with family resources as inputs. The relationships in the production process are depicted in Figure 1.

The factors that determine a child's nutritional status are hypothesized to operate as follows. First, parental decisions determine the allocation of family resources such as food, medical care, and parental attention. In making such decisions, parents are constrained by their available resources. How

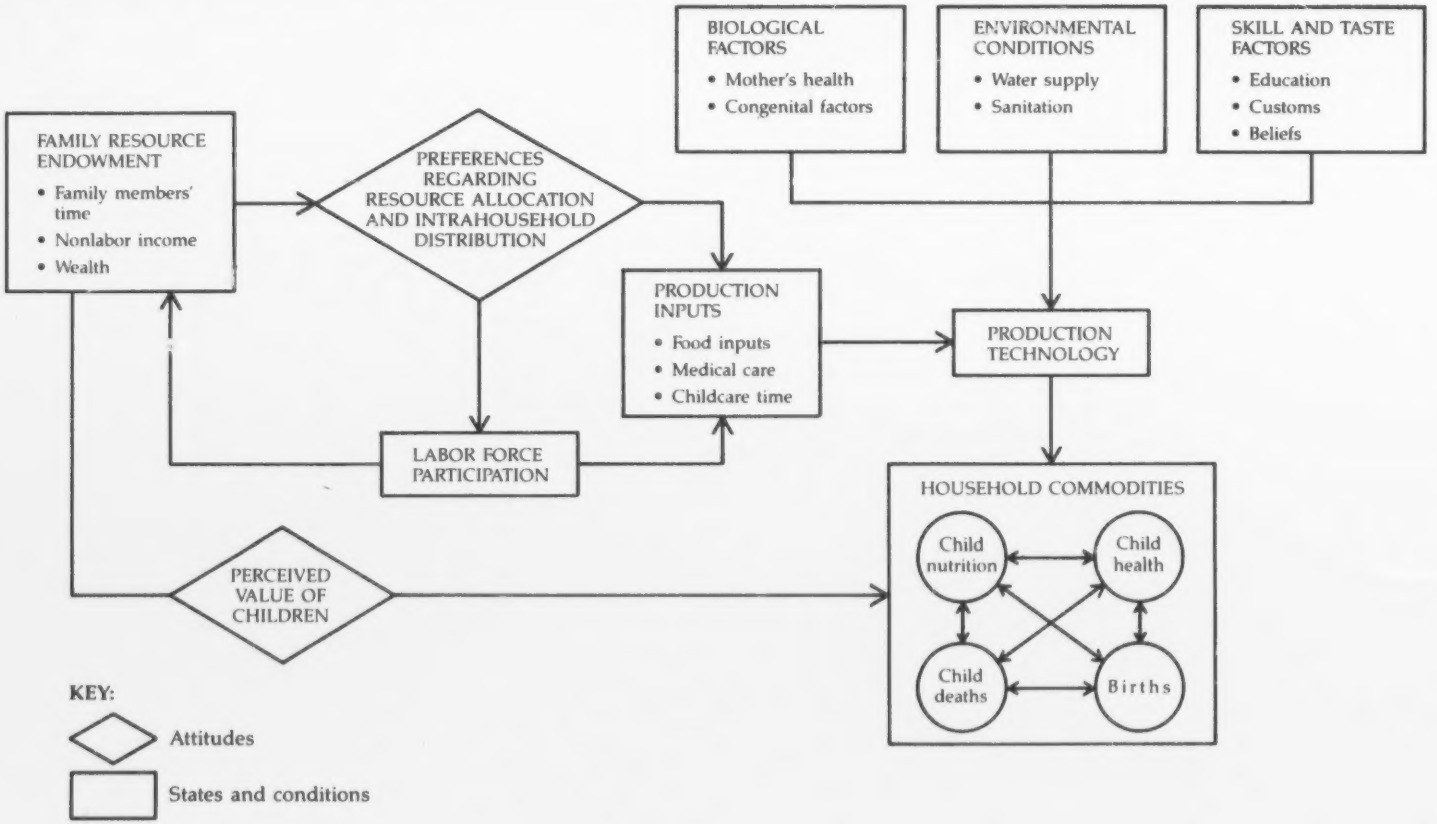

Figure. Model of interrelationships in the production of children's nutritional status

successful they are in using those resources in turn depends on their "home production technology"—their knowledge of childrearing and their overall skills. The effectiveness of that technology is affected by the child's general physical health, which may be the product of both environmental conditions (e.g., sanitation), and biological factors (e.g., the child's congenital condition), which may impede or assist in the production of nutritional adequacy.

In the model, births, deaths, health, and nutrition are closely intertwined, being simultaneously affected by parental decisions, regarding desired fertility and family resource allocation. Put in the form of an equation, the model hypothesizes that a child's nutritional status is determined as follows:

$$\text{Child's nutritional status} = f_1 [\text{nutritional input, child's health, child's death, births, biological factors, child-care time, technology factors}]$$

Food consumption is an obvious input, necessary for physical growth. Utilization of nutrients, however, is affected by the child's health and other biological factors such as the mother's health at the time of childbirth.

Biological factors are represented in the model primarily by characteristics that may be transmitted from mother to child. For example, an infant's size is known to be affected by maternal age and parity (Love and Kinch 1965; Morley 1973), and birth size is highly correlated with subsequent nutritional status. Mothers below 20 and above 35 years of age at the time of childbirth are at greater risk than other women of bearing children of low nutritional status, and being a mother's fifth or later child carries greater nutritional risk than being born in a lower birth order. High pregnancy wastage—experiencing fetal deaths and neonatal deaths—indicates poor maternal health and consequently poor health among children who survive. Close spacing of births may also harm a child's nutritional status, since medical evidence abounds (Hughes 1923; Douglas and Blomfield 1958; Morley 1973) showing that an interval of less than six months between a birth and the next conception can have a negative effect on the next child's weight.

The hypothesis advanced here, however, is that these physiological effects do not extend beyond the second year of life unless they are reinforced by behavioral factors. In other words, physiological effects are believed to be strongest in early childhood, which is defined as the first two years of life, and behavioral factors are hypothesized to dominate thereafter.

Behavioral influences are those that determine the quantity and quality of food consumed (including breastfeeding time), medical care, and

childcare time. The extent to which resources are devoted to each child depends on the time and other resources that the family has at its command. The resources actually allocated to each child are then influenced by parental knowledge and cultural practices or prejudices, by the degree of competition for those resources, and by the importance that parents attach to the individual child.

Thus parental behavioral influences are captured by several variables: whether the mother works in the informal sector (in activities that are compatible with childcare); her hours of work, if any, in the formal sector; the number of children under age 7 who compete for attention; and the number of children the parents regard as "in excess." Other child-specific variables include the length of the breastfeeding period, the child's sex, and the spacing between preceding and succeeding siblings, since close spacing is likely to lead to competition for parental attention and family resources. Wray (1971), for example, reports studies that show that successive children harm the nutritional status of preceding children.

The model further postulates that the mother's age (introduced as a continuous variable) can capture the effect of certain parental attitudes, such as fatalism or the perception that investments in children's "quality" (for example, education and nutrition) are likely to have a low rate of return.

The model postulates that the degree of competition for resources is also influenced by (current) child mortality in the family but the effect of mortality is ambiguous. On one hand, child loss may reflect congenital problems associated with maternal health. In such cases, the effect on nutritional status is expected to be negative. On the other hand, if child loss allows greater amounts of resources to be devoted to the survivors, then current mortality is expected to augment the nutritional status of the surviving children if the number of births is held constant so as to remove the "replacement motive" of an additional birth.

In recognition of the interrelatedness of the household commodities—child nutrition, child health, child death, and births—the following simultaneous equations were estimated, which allow for feedbacks and interactions:

(1) Child's nutritional status = f_1 [nutritional input, child's health, child's death, births, biological factors, childcare time, technology factors]

(2) Child's health status = f_2 [child's nutritional status, medical care, child's death, births, biological factors, childcare time, technology factors]

(3) Child deaths = f_3 [child's nutritional status, child's health, births, food intake, medical care, biological factors, childcare time, technology factors]

(4) Births = f_4 [nutritional status, child's health, child's death, total income, income by source, taste factors, biological factors]

The model is estimated at two levels: at the household level, where averages for nutritional status are used and health variables omitted because a suitable average measure is lacking for all the children in the household, and at the child level, where child-specific variables are used. In the household model, the determinants of nutritional status, child's death, and birth are estimated by two-stage least-squares regression because of the simultaneity postulated. In the child model, health status is added and is represented by a set of dichotomous variables, so that the probit maximum likelihood procedure is used to explore the determinants of health status and to obtain predicted values for health status, which are then used as instrumental variables in the second-stage regression for nutritional status. Similarly, death and birth are variables predicted from ordinary least-squares estimates to correct for the simultaneous-equation bias that would otherwise result.[4]

In the household model, *nutritional status* is represented by three variables that are averages for the household. The first is the average weight score of all the children in the household, each child's score being the weight of that child as a percentage of the reference weight for children of that age and sex. The mean score of the sample was 91.97 with a standard deviation of 9.85, reflecting the widespread prevalence of mild nutritional inadequacy. The second measure is the average height score of all the children in the household, each child's score being expressed as a percentage of the reference height for children of that age and sex. The mean score for this variable was 94.03 with a standard deviation of 4.56. The third measure is the average of the children's weight-for-height scores, each score expressed as a percentage of the reference weight for children of that height. This measure, which is a better indicator of nutrition than the other two measures, produced a mean value of 103.66, suggesting that severe chronic and persistent cases of malnutrition were infrequent in Ubon Rachathani Province.

4. Results of the child death and child health regressions are not reported in this paper. Interested readers are referred to Chutikul (1982).

In the child model the same three anthropometric measures are used, but the scores are child-specific. The mean scores were 91.04, 93.54, and 99.39 for weight-for-age and sex, height-for-age and sex, and weight-for-height respectively.

The *health status* variable appears only in the child model. A child's health is proxied by three dummy variables. The first is assigned a value of 1 if the child had more than four continuous days of diarrhea during the month immediately preceding the survey. The mean of 0.032 indicates that only 3.2 percent of the sampled children suffered from this problem. The second dummy variable is valued at 1 if the child had more than four continuous days of fever during the month immediately preceding the survey. The mean score was 0.061, indicating that only 6.1 percent of the children surveyed were afflicted with this condition. The third dummy variable assumes a value of 1 if the child had ever suffered from a chronic disease such as diphtheria, typhoid, or tuberculosis. The sample mean for this variable was 0.198.

Child mortality is represented by the number of deaths among children under 7 years old as a proportion of the total number of births in the family within the past seven years. This proportion is used to control for the fact that families with more births would have more children exposed to the risk of mortality. The incidence of child mortality in the sample was low, as expected, the sample mean being 0.011 with a standard deviation of 0.026.

Fertility is measured by the number of live births per year of exposure to conception in the last seven years. This measure of current fertility is selected because I hypothesized that current fertility had an interacting effect on the nutritional status of children under age 7. The sample mean was 0.473 with a standard deviation of 0.233.

Summary statistics and description of these variables and the exogenous variables are presented in Appendix Table 1.

FINDINGS

The analysis revealed the existence of moderate degrees of nutritional inadequacy, typical of the overall nutritional situation in Thailand. Severe cases of malnutrition were rare, but moderate deficiencies were widespread, with specific problems in certain nutrients and among particular groups of people. This general scenario is replicated regardless of the nutrition measure used.

In terms of the nutrient content of household intake per adult equivalent, the normalized sample means in Table 6 show that deficiencies occur in all the nutrients, the severest being in vitamin A, vitamin B2, and vitamin C. The low means combined with the small standard deviations im-

Table 6. Recommended nutrient requirements and normalized nutrient content of household consumption per adult equivalent among sample households

Nutrient	Recommended daily allowance[a]	Sample mean	Normalized sample mean	S.D.
Protein (gm.)	38	33	0.86	0.462
Calories (kc.)	1,955	1,922	0.98	0.388
Calcium (mg.)	480	420	0.87	0.200
Vitamin A (std. unit)	1,989	455	0.23	0.307
Vitamin B1 (mg.)	0.79	0.51	0.65	0.201
Vitamin B2 (mg.)	1.08	0.40	0.37	0.215
Niacin (mg.)	14	10	0.71	0.105
Vitamin C (mg.)	27	12	0.44	0.188

a. Obtained from the Nutrition Planning Division, National Economic and Social Development Board, Bangkok, 1975.

ply that the majority of the households consumed much less than the required amounts of these nutrients. For protein and calories, however, the sample means indicate average consumption levels that were only slightly below recommended standards. Calorie consumption was 98 percent of recommended allowances, and protein consumption was 86 percent of the standard. Averages can be misleading, however. The high standard deviations (0.462 for protein and 0.388 for calories) mean that large variations existed in the consumption of these two vital nutrients, and many families were likely to be suffering from severe deficiences.

Nutritional intake can be measured also by the household's monetary expenditure on food or by the food's imputed purchase value. I obtained the value of total food consumed by multiplying the quantities of food consumed by the average market price for each food group in the province. The latest available recommended minimum food budget for the Northeastern region was 116 baht (US $5.80) per month per person in 1975 (Krongkaew 1979). Even with an exaggerated inflation rate of 10 percent per annum, the sample mean of 276.09 baht per month in 1979 still represents an improvement. But the large standard deviation of 83.65 baht reflects substantial disparities in the living conditions of the sample families. As expected, lower-income households had to devote a greater proportion of their expenditure to food (Table 7).

Examination of the outcome measure—nutritional status—reveals a roughly similar picture. The distribution of the sampled children by their nutritional status (Table 8) shows that the weight measures, which indicate current nutritional status, present a generally more optimistic picture than

the height measures, which reflect long-term conditions. The weight-for-age criterion classifies 48 percent of the children as malnourished, though less than 1 percent are in the severe, third-degree category. Nevertheless, a large proportion, 61 percent, were found to be malnourished according to the height-for-age measure, though only 5 percent of them were in the third-degree group. These results were not surprising since the survey was undertaken immediately after the harvest period when current consumption levels are likely to be above average. But they suggest that patterns of consumption may be erratic from one season to another, whereas regularity of intake is important for growing children.

Table 7. Food expenditure as a percentage of total expenditure on current consumption, by income class and number of adult equivalents

Income class (baht equivalent)[a]	%, by number of adult equivalents				
	<3	3–3.9	4–4.9	5–5.9	≥6
<5,000	78.1	76.6	79.3	83.1	84.8
5,000–9,999	74.3	74.8	77.9	81.7	82.1
10,000–14,999	72.5	72.8	74.0	79.1	80.9
15,000–19,999	70.5	72.2	75.2	77.4	79.1
≥20,000	67.7	69.0	71.3	72.4	74.5
No. of households in sample	105	122	137	99	119

a. Includes all income in cash and kind.

Table 8. Sampled children, by nutritional status and standard measure

Nutritional status	Weight for age		Height for age		Weight for height	
	No. of children	%	No. of children	%	No. of children	%
Normal +	321	23	173	12	413	29
Normal -	421	30	383	27	600	42
First degree	568	40	516	36	354	25
Second degree	98	7	278	20	44	3
Third degree	8	*	66	5	5	*
Total	1,416	100	1,416	100	1,416	99

Note: Percentages may not sum to 100 because of rounding.

* Less than 1 percent.

Causes of child malnutrition

Child malnutrition can be ascribed to five main factors: poverty, mother's choice about labor force participation, sibling competition, some physiological factors, and ignorance. In my sample, behavioral factors generally tended to outweigh physiological effects, particularly among older children. The effects of poverty, ignorance, and physiological factors can perhaps be expected, but the detrimental effects of a mother's work choice warrant attention.

Poverty and child malnutrition

Low income—poverty—was found to limit the nutritional intake of the sampled families. As expected, poor families consumed less of all kinds of food and consumed nutritious foods (particularly high-protein foods such as meat) less frequently than better-off families, and their children were consequently less well nourished. The income elasticity of food consumption is low; that is, as income rises, food consumption also increases but does so at a lower percentage rate. Hence very substantial increases in income are needed to bring about improved nutrition.

Regression estimates of the determinants of nutritional status (Table 9) show that families that spent more income on food per adult equivalent were better able to feed their young than were other families. Children in those families were better off nutritionally; both average weight for age and average weight for height were increased by the higher expenditure on food. Children's average height for age, however, was not significantly affected. These findings are plausible because the weight measures are more likely than the height measure to reflect current intake, and current expenditure on food is a measure of current intake.

Families with high food expenditures were those with high income and large landholdings. Regression analysis of food expenditure and the normalized intake of protein on household characteristics (Table 10) shows that families with large planted areas of land spent significantly more money on food and consumed more protein than other families. (Protein was chosen as the representative nutrient because protein–calorie malnutrition is the main concern of the study and the simple correlation between protein and calorie consumption was very high—0.94.) Households with higher farm income also spent more on food. It is noteworthy that the same socioeconomic characteristics—higher income or wealth and nonfarm occupation—tended to have similar augmenting effects on food expenditure and protein consumption. But in spite of income's importance in determining the amount of food consumed, the elasticity of food expenditure with respect to income is less than one would expect. The elasticity of food expenditure with respect to farm income, evaluated at sample means, was

Table 9. Household model: two-stage least squares regression estimates of nutritional status equations

Right-hand variables	Weight score		Height score		Weight-for-height score	
Child mortality	2.01380	(.3682)	4.78900	(1.65890)	-6.41230	(-.8976)
Current births	-.34875	(-.2984)	2.35700	(1.99030)	-6.54610	(-2.3544)
Months of breastfeeding	.00040	(.0099)	-.09832	(-1.93340)	.09335	(1.9433)
Hours of work	-2.95780	(-3.7875)	-1.53420	(-3.45380)	-.33112	(-.2234)
Work in informal sector	12.26700	(14.1780)	3.42310	(10.25900)	3.32250	(2.9236)
Food expenditure per adult equivalent	.01780	(2.6873)	.00084	(.00288)	.02756	(3.7811)
Mother's age	-.05785	(-.6667)	-.11294	(-2.33980)	1.31220	(10.7490)
Excess number of children	.09234	(.3622)	-.29770	(-1.23930)	1.05030	(2.3794)
Age <20 at first childbirth	-.13779	(-.1579)	-1.21890	(-2.54780)	7.22310	(5.2398)
Age >35 at first childbirth	-.27885	(-.1711)	-.18240	(-.32217)	-13.03480	(-1.3281)
Priority given to feeding children	2.03470	(.4999)	.44255	(.17380)	1.35690	(.1993)
Constant	83.23400	(19.7220)	89.39400	(38.65800)	57.32300	(10.4345)
No. of observations						582

Note: Figures in parentheses are asymptotic ratios; therefore no significance levels are given.

Table 10. Household model: ordinary least squares regression estimates of food expenditure and normalized protein intake per adult equivalent

Dependent variable	Food expenditure			Protein intake		
	Coefficient	Asymptotic *t*-ratios	Elasticity at means	Coefficient	Asymptotic *t*-ratios	Elasticity at means
Mother's age (MAGE)	2.89511	(1.8574)	.32035	.02008	(1.0322)	.71340
Value of farm production (FPRODV)	.00437	(3.7589)*	.17511	.00007	(2.0239)*	1.02230
Nonfarm income (NFY)	.00051	(.8763)	.01215	.00004	(.7960)	.32500
Predicted mother's wage (PRMWAGE)	-1.50633	(-2.6540)*	-.32512	.00419	(1.1031)	.29050
Ignorance variable (KM1)	-1.85254	(1.3038)	-.05990	-8.66980	(1.8038)	-1.12910
Ignorance variable (KM2)	-5.24654	(-1.7654)	-.00629	-.26605	(-1.0392)	-.10240
Wealth index 1	4.30376	(1.2311)	.00053	1.16370	(1.1502)	.04601
Wealth index 2	-12.83810	(1.5987)	-.00093	1.39970	(2.5022)*	.03255
Wealth index 5	28.16120	(3.4420)*	.00051	1.45170	(.9428)	.00844
Planted area (PLAREA)	.19769	(4.3223)*	.05112	.00570	(2.3209)*	.46981
Farm occupation (OCCUF)	-70.80580	(-7.1865)*	-.18542	-.38759	(-2.0211)*	-.32585
Father's education (EDFA)	2.24053	(1.0047)	.03522	.31389	(1.2337)	.08410
Constant	263.92110	(15.1980)		-1.38270	(-1.9180)	
No. of observations	582			582		
R^2	.20			.19		
F-statistic	11.70*			10.14*		

* Significant at the 5 percent level.

0.18, consistent with findings from other studies in Thailand (for example, Konjing 1981). But the elasticity has to be interpreted in relation to labor's share of income, since planted area can be considered a proxy for other factors of production.

The effect of nonfarm income may be confounded with the effect of wealth (Table 10). Nonfarm income seems to have had no discernible effect on food expenditure, but possession of small consumer items (wealth index 5) appears to have augmented food consumption somewhat. (Details on the construction of the wealth indexes are presented in Appendix Table 2.) On the other hand, this finding may suggest that income from nonagricultural sources tended to be used for purposes other than food.

Farm families also tended to be less well off than others in their food consumption. This observation, in conjunction with the result that farm production value increased nutritional intake, suggests that the income effect tended to outweigh the adverse effect of having farming as an occupation. In other words, farm families tended to consume less food than families in other occupations, but among the farm families those whose farm production was large enough consumed more food than others. It appears then that the poorer farmers with small landholdings and low output were the worst off.

Mother's work and child nutrition

A major finding of this study is that maternal labor force participation had an important effect on child nutrition. In developing countries it is common for women to work in so-called informal-sector occupations that are compatible with childcare. About 48 percent of the women in the present sample worked solely in such jobs as raising silkworms, weaving and spinning, making mats and baskets, and running small grocery stores in the home; and they were found to take better care of their children nutritionally than women who were employed in formal jobs, which included farm labor and work in small retail and service stores (such as hairdressers). Thus a mother's choice of work activity was found to have important consequences for her children.

Jaffe and Azumi (1960) and Hass (1972) found that women working in informal-sector jobs had higher fertility than women working in the formal sector. In order to achieve a reduction in fertility they recommended that formal-sector jobs be created to draw women away from the home. Although the present study provides mild support (equations not shown) for the hypothesis that formal-sector work induces a fertility decline, the findings indicate more importantly that a mother's switch from an informal-sector to a formal-sector job is detrimental to her children's "quality," measured by nutritional status. As Table 9 shows, informal-sector work that in-

volved mothers in activities that did not conflict with childcare increased significantly all three measures of nutritional status. If a mother worked in the home, the average nutritional status of her children was up to 12 percentage points higher than if she worked away from home.

Moreover, the longer her hours of work in the formal labor market, the lower were the average weight-for-age and the average height-for-age of her children. The magnitude of the effect was considerable. A coefficient of -1.534 for hours of work in the height score regression (Table 9) indicates that, other things being equal, a mother who spent thirty hours a week in a formal-sector job had children whose average height score was 46 percentage points lower than that of children whose mothers did not work in the formal sector. Of course, the effect may be exaggerated since nonlinearities are not taken into account here. It is possible that the effect may diminish as the number of hours in the formal sector increases.

Two possible explanations for the adverse effect of formal-sector work on child nutrition are that not enough of the income from formal-sector work was spent on inputs that would augment children's nutrition, or that purchased inputs were not good substitutes for the mother's time spent in producing good nutrition. Whatever the correct explanation may be, it has important policy implications in view of the seriousness of childhood malnourishment on later physical and mental development. Where policies exist to raise or reduce fertility by encouraging women to work in the formal sector, policymakers must be cognizant of the adverse effect of such work on children's nutritional status so that proper preventive measures can be incorporated into the policies.

When the individual child was the unit of analysis, the effect of informal-sector work on child nutrition was confirmed. Child nutrition was enhanced substantially when the mother worked in the home (Tables 11 to 16). The effect was more pronounced for very young children, whose nutritional status score improved up to about 20 percentage points, depending on the measure used. This is a reasonable finding, since very young children are more likely than older children to be in need of their mother's care, being less able to fend for themselves and defend their share of food intake.

Sibling competition and malnutrition

The analysis revealed that high fertility was not conducive to good nutrition. Other things being equal, larger families had more malnourished children than smaller families. Families with many young children were more likely to have children with low weight-for-height scores (Table 10). This finding suggests competition for resources among the young children. Sibling competition was even more apparent when the individual child was

Table 11. Child-specific regression: final-stage results for children of ages 0 to 3, with weight for age as the dependent variable

Independent variable	Coefficient, by age			
	0	1	2	3
Predicted incidence of diarrhea	4.24160 (1.24280)	5.3919 (.6952)	**	6.60980 (1.60640)
Predicted incidence of fever	-30.37600 (-5.79640)	-26.7970 (-4.9736)	-42.69800 (-8.07300)	-12.71400 (-3.78300)
Predicted incidence of disease	-14.59000 (-2.14860)	13.7260 (1.3266)	-3.43200 (-.48270)	-18.42800 (-4.67400)
Predicted incidence of mortality	-34.19200 (-2.64830)	-30.1960 (-5.2763)	10.54500 (2.10910)	15.34900 (2.18200)
Predicted incidence of fertility	-8.38120 (-.57380)	-67.8280 (-6.9450)	6.12220 (.34024)	-90.00700 (-5.21100)
Proportion of life breastfed	-.01862 (-.39820)	1.5425 (1.1734)	-1.02210 (-.44010)	-7.12350 (-4.08800)
Hours of work	.00180 (.00860)	-.1203 (-.8783)	.43486 (1.62900)	-.11999 (-1.05800)
Work in informal sector	17.50200 (3.88400)	6.8612 (2.0791)	19.21300 (3.20700)	2.64420 (.87750)
Food expenditures	-.00021 (-.01410)	.0205 (2.0028)	.01332 (1.45980)	.01302 (1.83880)
Mother's age	.02264 (.06410)	-.2924 (-1.1973)	-.36697 (-1.37100)	-.81221 (-3.21600)
Excess number of children	-.61682 (-1.06610)	-.2967 (-.6363)	.09057 (.12477)	.91258 (1.46990)
Mother's age <20 at childbirth	2.43570 (.81210)	13.2340 (5.5435)	-.62714 (-.19140)	-3.39380 (-1.66700)
Mother's age ≥ 35 at childbirth	5.76710 (1.07930)	5.0105 (1.4033)	2.12120 (.71122)	.42060 (.17868)
Space before birth	-.25548 (-.91670)	.0648 (.9422)	-.01272 (-.12150)	.13205 (2.81330)
Space after birth	.04715 (1.13810)	-.0848 (-3.0606)	.02979 (.40648)	-.06937 (-2.16300)
Pregnancy order	.30880 (.64760)	1.2613 (2.6600)	-.58809 (-1.83050)	2.87410 (3.82730)
Female child	-1.29630 (-.82010)	-1.2065 (-.9345)	-.08432 (-1.02300)	.33490 (1.21230)

Table 11. (*continued*)

Independent variable	Coefficient, by age			
	0	1	2	3
Constant	98.75900	123.4300	87.64100	156.94000
	(4.62670)	(10.4780)	(6.28200)	(10.43400)
N	151	167	145	144

Note: In this and subsequent regression tables, figures in parentheses are asymptotic *t*-ratios.

** The first-stage probit regression does not converge. Consequently, the variable representing predicted incidence of diarrhea, which appears in the other equations, is dropped from subsequent analyses for this age group.

Table 12. Child-specific regression: final-stage results for children of ages 4 to 6 and 0–6 combined, with weight for age as the dependent variable

Independent variable	Coefficient, by age			
	4	5	6	0–6
Predicted incidence of diarrhea	8.28620	-4.09800	8.33470	5.78400
	(1.85410)	(-1.28600)	(1.72550)	(1.45910)
Predicted incidence of fever	-14.68300	**	-17.21400	-10.40800
	(-4.47400)		(-6.16700)	(-2.67600)
Predicted incidence of disease	.86825	-.78706	2.77040	-6.57960
	(.16310)	(-.12720)	(.55720)	(-1.13700)
Predicted incidence of mortality	48.24800	70.57100	22.66000	-23.30300
	(5.63900)	(6.21880)	(2.09170)	(-2.23900)
Predicted incidence of fertility	-77.15100	97.19300	-40.97900	-51.53800
	(-5.75200)	(6.29230)	(-1.91700)	(-2.23100)
Proportion of life breastfed	-3.55130	-6.51270	1.34760	.70211
	(-2.15200)	(-3.57400)	(.50720)	(4.07980)
Mother's hours of housework	-.40361	.16461	-.41250	-.07284
	(-3.06900)	(1.57650)	(-2.18500)	(-1.15900)
Mother's work in informal sector	13.66100	21.57300	2.55740	13.50500
	(4.14640)	(6.60970)	(.52050)	(8.31970)
Food expenditures	.03789	.03934	.02198	.01332
	(5.69990)	(5.46490)	(1.81560)	(1.69110)
Mother's age	.55753	1.11620	.27639	-.40885
	(2.70870)	(4.54360)	(1.32370)	(-1.79900)

Table 12. (*continued*)

Independent variable	Coefficient, by age			
	4	5	6	0–6
Excess number of children	2.63560 (4.18000)	-.05250 (-.11080)	2.18950 (1.29330)	.53302 (1.58770)
Mother's age < 20 at childbirth	9.47330 (4.19850)	-4.52270 (-2:10810)	2.08140 (.63470)	3.93050 (1.85240)
Mother's age > 35 at childbirth	-8.65080 (-3.18200)	-11.02200 (-4.02230)	-9.22530 (-1.78900)	2.96170 (1.86100)
Space before birth	.11674 (1.60840)	-.07352 (-1.80630)	.00928 (.15560)	.04087 (1.18580)
Space after birth	.14258 (4.34570)	.12400 (4.18240)	-.01368 (-.34600)	-.00594 (-.45640)
Pregnancy order	3.23830 (4.62810)	-3.67840 (-5.63870)	.05804 (.09971)	1.03640 (1.92330)
Female child	1.23800 (.98340)	1.38730 (1.20380)	.98504 (1.02930)	-.01494 (.02973)
Constant	99.79300 (13.36200)	5.99890 (.45250)	101.41000 (7.05900)	122.18000 (5.92890)
N	144	146	109	1,006

** See note in Table 11.

Table 13. Child-specific regression: final-stage results for children of ages 0 to 3, with height for age as the dependent variable

Independent variable	Coefficient, by age			
	0	1	2	3
Predicted incidence of diarrhea	-.74370 (-.44790)	5.39190 (.69520)	**	-.02194 (-.00640)
Predicted incidence of fever	-6.37670 (-2.50090)	-26.79700 (-4.97300)	-14.55200 (-3.71500)	-3.15130 (-1.11800)
Predicted incidence of disease	2.29100 (.69340)	13.72600 (1.32660)	-7.94780 (-1.50900)	-3.79230 (-1.14700)
Predicted incidence of mortality	-1.52010 (-.24190)	-30.19600 (-5.27600)	7.88310 (2.12900)	2.34140 (.39690)
Predicted incidence of fertility	24.67100 (3.47130)	-67.82800 (-6.94500)	9.42600 (.70730)	-27.12400 (-1.87200)

Table 13. (*continued*)

Independent variable	Coefficient, by age			
	0	1	2	3
Proportion of life breastfed	.01454 (.13810)	1.54250 (1.17340)	-.17795 (-.10350)	-1.71620 (-1.81100)
Mother's hours of housework	.08357 (.00860)	-.12026 (-.87830)	.20694 (1.04670)	-.08019 (-.84370)
Mother's work in informal sector	8.92520 (4.07100)	6.86120 (2.07910)	12.76400 (2.88780)	1.79410 (.70990)
Food expenditures	.01905 (2.58680)	.02045 (2.00280)	.00389 (.57873)	-.00078 (-.13170)
Mother's age	.32924 (1.91700)	-.29235 (-1.19700)	-.38135 (-1.92400)	-.33502 (-1.58200)
Excess number of children	-.38481 (-1.36700)	-.29670 (-.63630)	-.09105 (-.16870)	.26598 (.51080)
Mother's age <20 at childbirth	-2.92810 (-2.00640)	-.45234 (-.27150)	-2.85680 (-1.17300)	-1.58090 (-.92570)
Mother's age >35 at childbirth	-1.66760 (-.64140)	-4.11920 (-1.65300)	.95040 (.42860)	.80317 (.40680)
Space before birth	.06829 (.50360)	.05358 (1.11530)	.03729 (.48068)	.04067 (1.03310)
Space after birth	-.02059 (-1.02140)	-.00409 (-.21570)	.05800 (1.06430)	-.02835 (-1.05400)
Pregnancy order	.40363 (1.73960)	.10753 (.32495)	.04604 (.19273)	.80832 (1.28340)
Female child	-.93840 (-1.57380)	-1.39480 (-1.83740)	-1.37480 (-.95670)	.95782 (.92830)
Constant	63.37000 (6.10160)	91.00800 (11.07100)	92.88200 (8.98930)	114.05000 (9.04000)
N	151	167	145	144

** See note in Table 11.

Table 14. Child-specific regression: final-stage results for children of ages 4 to 6 and 0–6 combined, with height for age as the dependent variable

Independent variable	Coefficient, by age			
	4	5	6	0–6
Predicted incidence of diarrhea	.42954 (.15040)	-4.74390 (-2.31530)	-2.47140 (-.79880)	-2.79970 (-.92410)
Predicted incidence of fever	-4.11410 (-1.96200)	**	-3.03450 (-1.69730)	-3.16190 (-1.53700)
Predicted incidence of disease	1.38550 (.40720)	.44050 (.11120)	1.70500 (.53540)	-8.18670 (-2.34900)
Predicted incidence of mortality	-9.25330 (-1.69300)	17.37900 (2.39160)	12.04700 (1.73630)	-12.68800 (-2.02300)
Predicted incidence of fertility	-15.34800 (-1.79400)	15.57400 (1.57450)	-18.82500 (-1.37500)	-37.46000 (-2.69200)
Proportion of life breastfed	-1.08040 (-1.02400)	-2.23610 (-1.91700)	-2.46350 (-1.44800)	.34855 (3.36180)
Mother's hours of housework	-.17678 (-2.10400)	.02087 (.30340)	-.26684 (-2.20600)	-.09746 (-2.57600)
Mother's work in informal sector	2.84260 (1.35030)	7.26000 (3.47370)	-.45308 (-.14390)	5.35720 (5.47800)
Food expenditures	.00596 (1.40210)	.00602 (1.30620)	-.00860 (-1.10900)	-.00858 (-1.81000)
Mother's age	.24381 (1.85380)	.15420 (.98020)	.21174 (1.58320)	-.45252 (-3.30500)
Excess number of children	.04404 (.10930)	.29190 (.96210)	1.11580 (1.02900)	.17942 (.88710)
Mother's age <20 at childbirth	2.51290 (1.74300)	-.48747 (-.35480)	3.19470 (1.52100)	1.53200 (1.19850)
Mother's age >35 at childbirth	-3.78140 (-2.17800)	-2.48420 (-1.41600)	-4.04320 (-1.22400)	2.47840 (2.58490)
Space before birth	-.01462 (-.31530)	-.02329 (-.89390)	.06534 (1.70900)	.06234 (3.00190)
Space after birth	-.00566 (-.26980)	.02583 (1.36030)	.02532 (1.00020)	.01571 (2.00220)
Pregnancy order	.88350 (1.97610)	-.55948 (-1.33900)	-.03892 (-.10440)	1.03660 (3.19330)

Table 14. (*continued*)

Independent variable	Coefficient, by age			
	4	5	6	0–6
Female child	-1.87640	-.98675	-.65212	.34217
	(-.90010)	(-.87780)	(-1.09900)	(1.09190)
Constant	90.89700	80.54200	103.49000	126.67000
	(19.04900)	(9.48700)	(11.24700)	(10.20300)
N	144	146	109	1,006

** See note in Table 11.

Table 15. Child-specific regression: final-stage results for children of ages 0 to 3, with weight for height as the dependent variable

Independent variable	Coefficient, by age			
	0	1	2	3
Predicted incidence of diarrhea	1.72970	3.60950	**	6.40620
	(.91660)	(.40890)		(1.15930)
Predicted incidence of fever	-8.23900	-17.14300	-29.31200	-14.46300
	(-2.84330)	(-2.79540)	(-4.67800)	(-3.20400)
Predicted incidence of disease	-1.43640	.14321	-2.13610	-14.79500
	(-.38260)	(.01220)	(-.25350)	(-2.79400)
Predicted incidence of mortality	-8.23100	-14.34100	6.80450	-16.79800
	(-1.15290)	(-2.20160)	(1.14440)	(-1.77800)
Predicted incidence of fertility	-14.24100	-32.08600	7.22850	-56.76900
	(-1.77560)	(-2.88640)	(.33779)	(-2.44700)
Proportion of life breastfed	-.48257	-1.48040	-.79435	-2.97830
	(-4.03150)	(-.98940)	(-.25500)	(-1.27200)
Mother's hours of housework	.13319	-.01060	.39872	-.00781
	(-1.16210)	(-.06780)	(1.25590)	(-.65560)
Mother's work in informal sector	-.68384	1.69270	13.57700	1.47310
	(-.27450)	(.45060)	(1.91300)	(.36399)
Food expenditures	-.00318	.02415	.01527	.02522
	(-.37980)	(2.07810)	(1.41270)	(2.65140)
Mother's age	.02989	-.02505	-.03889	-.52863
	(.15320)	(-.09012)	(-.12220)	(-1.55900)
Excess number of children	-.10414	.60649	-.67892	.76046
	(-.32550)	(1.14260)	(-.78640)	(.91199)

Table 15. (*continued*)

Independent variable	Coefficient, by age			
	0	1	2	3
Mother's age <20 at childbirth	2.35890 (1.42230)	11.66400 (4.29250)	.75614 (.19407)	-3.82830 (-1.39900)
Mother's age >35 at childbirth	-.91420 (-.30940)	1.55380 (.38232)	-1.34220 (-.37840)	2.35680 (.74550)
Space before birth	-.11873 (-.77080)	-.02894 (-.36940)	-.04486 (-.36140)	.00984 (.15610)
Space after birth	.02565 (1.11970)	-.05065 (-1.60670)	.04729 (.54247)	-.06357 (-1.47600)
Pregnancy order	-.03981 (-.15100)	.42183 (.78158)	-.44045 (-1.15300)	1.85010 (1.83430)
Female child	-1.60480 (-1.85500)	-1.37800 (-.98370)	-.39840 (-1.29700)	.98347 (1.08230)
Constant	98.15800 (8.31640)	102.89000 (7.67360)	84.46300 (5.11050)	143.88000 (7.12230)
N	151	167	145	144

** See note in Table 11.

Table 16. Child-specific regression: final-stage results for children of ages 4 to 6 and 0–6 combined, with weight for height as the dependent variable

Independent variable	Coefficient, by age			
	4	5	6	0–6
Predicted incidence of diarrhea	9.85420 (1.61280)	.11024 (.02860)	15.52300 (2.33870)	7.15250 (1.08910)
Predicted incidence of fever	-14.14800 (-3.15300)	**	-18.78300 (-4.89700)	-7.57760 (-2.01100)
Predicted incidence of disease	-.13655 (-.01870)	1.44720 (.19330)	2.04760 (.29970)	19.21300 (2.52630)
Predicted incidence of mortality	-29.87600 (-2.55400)	69.53300 (5.06280)	2.91050 (.19550)	19.00000 (1.38840)
Predicted incidence of fertility	-41.62100 (-2.27300)	104.52000 (5.59120)	2.36050 (.08040)	34.79700 (1.14570)
Proportion of life breastfed	-2.35740 (-1.04500)	-4.93040 (-2.23600)	6.18890 (1.69520)	-1.70300 (-7.52500)

Table 16. (*continued*)

Independent variable	Coefficient, by age			
	4	5	6	0–6
Mother's hours of housework	-.30250 (-1.68200)	.20823 (1.64780)	-.17290 (-.66640)	-.03333 (-.40360)
Mother's work in informal sector	7.16050 (1.58970)	18.20200 (4.60800)	3.19270 (.47290)	3.28670 (1.53980)
Food expenditures	.03677 (4.04510)	.04813 (5.52430)	.04969 (2.98730)	.05743 (5.54580)
Mother's age	.60987 (2.16720)	1.43960 (4.84190)	.07623 (.26570)	1.45090 (4.85600)
Excess number of children	1.51880 (1.76190)	-.31715 (-.55310)	-.87068 (-.37430)	.25958 (.58800)
Mother's age < 20 at childbirth	7.31580 (2.37150)	-2.34220 (-.90200)	-4.57940 (-1.01600)	4.34040 (1.55560)
Mother's age > 35 at childbirth	-4.80380 (-1.29200)	-13.15600 (-3.96700)	1.04390 (.14730)	-11.29400 (-5.39700)
Space before birth	-.00201 (-.02020)	-.06876 (-1.39600)	-.12535 (-1.52900)	.01321 (.29150)
Space after birth	.09304 (2.07420)	.10695 (2.98050)	-.04884 (-.89920)	-.06750 (-3.94200)
Pregnancy order	1.21900 (1.27420)	4.01190 (5.08140)	-.21533 (-.26920)	-1.53300 (-2.16400)
Female child	.40389 (1.03840)	.48759 (.49380)	1.26340 (1.04890)	-2.58710 (-3.78200)
Constant	103.54000 (10.14100)	7.61320 (.47440)	97.92700 (4.96110)	26.37100 (.97320)
N	144	146	109	1,006

** See note in Table 11.

the unit of analysis. The fourth rows of Tables 11 to 16 show how the incidence of death in the household affected surviving children's nutritional status. (Child mortality was defined as the predicted number of deaths to 6-year-olds and under, as a proportion of total births during the last seven years.) An interesting pattern emerges. For children less than 2 years old, the effect of child mortality on nutritional status (when significant asymptotically) was invariably negative. For children of older ages, the effect was reversed and the coefficients were almost always positive. The only excep-

tion was the effect of mortality on weight-for-height scores, shown in Table 16. Both physiological and behavioral mechanisms may have been at work here. Weak, malnourished mothers are more likely than healthy mothers to produce babies who do not survive. High mortality in the home may thus reflect congenital health problems that impair a child's nutritional status in early infancy, the period in which physiological effects are likely to dominate. Hence, the effect of child mortality was negative in the first two years. For surviving children beyond age 2, however, high child mortality may allow them to receive more attention and thus to have better nutritional status as a result of diminished sibling competition. Of course, no parent is assumed to cause a child's death intentionally (although in some societies selective neglect is common and condoned), but in the face of limited resources, child neglect may occur. Thus a child's nutritional status varies inversely with the number of siblings present in the home.

The results of the fertility equation show that farm families with large land holdings (planted area) had higher fertility than other families. The fitted two-stage least-squares equation used for fertility was:

$$\begin{aligned} BRTH = {} & -1.398 - .006\ \text{weight} + .022\ \text{height} + .004\ \text{weight for height} \\ & + .006\ \text{predicted mother's wage} - .202\ \text{incidence of death} \\ & - .025\ \text{mother's age} - .00005\ \text{farm production value}^{*} \\ & - .000\ \text{nonfarm income} + .001\ \text{planted area}^{*} \\ & + .013\ \text{childcare alternative} + .213\ \text{farm occupation}^{*} \\ & + .007\ \text{father's education} - .055\ \text{program status} \end{aligned}$$

where * denotes significance at the 5 percent level only in the asymptotic sense.

The value of farm production tended to reduce recent fertility. This negative relationship is common where the economic value of children is perceived to be high (Rosenzweig 1977). If children assist their parents in production, then children can be viewed as income-generating assets that take the place of income from other sources. Thus parents with high earnings may be expected to depend less on their children as income-earners than do parents with low earnings. Where the economic value of children is high and children are viewed as productive agents who augment family income, a negative relationship between income and fertility is likely to exist. For poor families, children tend to be investment goods as well as consumption goods, providing not only child labor but also the potential for old-age support. In societies where institutionalized forms of old-age security do not exist, children are often the sole supporters of their parents in old age.

Physiological factors and malnutrition

The role of physiological factors in determining the nutritional status of children in the sampled families is uncertain. Neither close birth intervals nor high pregnancy wastage seem to have affected the nutritional status of succeeding children. Nor did the mother's age at childbirth or the pregnancy order have a systematic effect. Mothers who had closely spaced pregnancies did not, as a group, appear to have more malnourished children than other mothers, and mothers with a record of high child loss tended to have children of weak nutritional status only in the children's first two years of life. These findings suggest that proper care and nurture can rehabilitate children who have been previously malnourished.

According to my hypothesis, the longer the interval of recuperation between births, the healthier the mother would be and the higher would be the nutritional status of her children, particularly in early infancy. The results here were mixed (Tables 11 to 16). The longer the interval before a particular birth ("space before birth"), the higher was the expected score on nutritional status. Spacing after a particular birth was a proxy for the extent of sibling competition for family resources, and its coefficient was also expected to be positive. No systematic pattern emerged, however.

A pregnancy order of greater than four was included to reflect the mother's physical condition, because it takes into account the total number of pregnancies previously experienced by the mother and not just those terminating in a live birth. An anomalous result was again obtained. Children whose pregnancy order was greater than four appeared to be better off nutritionally than other children. (Birth order was dropped from the analysis because of poor results.)

Where physiological effects appear to have been of some importance, the effect was ambiguous. For example, medical literature indicates that mothers giving birth at ages less than 20 or greater than 35 are more likely than women in the prime childbearing ages to produce children of low birth weight, and I hypothesized that this disadvantage would be reflected in the nutritional status scores at least for children in the first two years. But the height-for-age and weight-for-height scores were affected in opposite directions (Table 9) in this sample. Mothers less than 20 years old at first childbirth had children who were significantly shorter than others in the base group (those 20 to 35), but their children tended to have greater weight for their height. It may be that any effect of a mother's age at childbirth is obscured by the averaging of nutritional status scores for all the young children in the family, but that seems doubtful. Child-specific analysis also produced mixed results. In Tables 11 to 16 mother's age at childbearing is child-specific, and no systematic pattern emerges.

It is possible that physiological effects are counteracted by parental behavior and that behavioral patterns dominate. Age at childbearing can be associated with two factors: the mother's physiological characteristics, and parental expectations of returns from children. Medical studies (e.g., Love and Kinch 1965) indicate that a very young mother is likely to produce small babies. But this physiological effect is likely to have a more detrimental effect on height than on weight. A weight deficit can be remedied more easily by current behavior and is more likely to be influenced by current expected returns. Thus young mothers (with longer time horizons) are more likely than older mothers to invest in the nutritional status of their children. This hypothesis is supported by the finding that mothers over age 35 at first childbirth tended to have children of low weight for height (column 3, Table 9).

Medical evidence indicates that a child's susceptibility to disease and infection is heightened if the mother is malnourished during pregnancy. Miscarriages and stillbirths are more prevalent among diet-deficient mothers, and these variables are used as proxies for the mother's nutritional status. The greater the number of abnormal births experienced by a mother, the greater is the expected susceptibility of her children to disease. Again, however, the regressions detected no strong influence (equations not shown). This finding suggests that once a child is born, the parents may insulate it from illness by providing the child with proper nutrition, medical attention, and general care.

Ignorance and malnutrition

There is evidence (for example, Durongdej 1982) that children may suffer nutritionally if mothers are ignorant of proper childfeeding practices. Though breastfeeding is beneficial in itself, it can be harmful if continued too long without supplemental foods. In a low-income rural setting, many mothers continue to breastfeed well beyond the normal weaning age of six months recommended by modern medical findings. If the practice could be traced to ignorance rather than to low income, then nutrition education would play an important role in presenting it.

The present study found that older children who had been breastfed for longer periods were worse off nutritionally than other children (Tables 11 to 16). The average number of months of breastfeeding per child was 20.10 with a standard deviation of 8.79 months. This means that some children were breastfed well into their third year. That supplemental foods are needed after a child reaches six months of age was not widely recognized among the mothers surveyed. But mothers who had come into contact with medical programs breastfed for shorter periods, on the average, than other mothers (Table 17). This finding is a sign that mothers in traditional set-

Table 17. Household model: results of ordinary least squares regression, with average number of months of breastfeeding per child as the dependent variable

Independent variable	Coefficient	*t*-ratio	Elasticity at means
Mother's age	-.54543	(-2.3502)*	-.83006
Value of farm production	.00002	(.3368)	.01206
Nonfarm income	-.00001	(-.9121)	-.00595
Predicted mother's wage	-.27692	(-2.7959)*	-.82196
Wealth index	-.08634	(-.1677)	-.00014
Wealth index 1	-.39197	(-.7244)	-.00078
Wealth index 2	-.12799	(-.2224)	-.00013
Wealth index 3	-1.36900	(-2.1252)*	-.00188
Wealth index 4	-.16675	(-.1865)	-.00004
Planted area	.00134	(1.1251)	.00475
Childcare	-.86496	(-1.1562)	-.02339
Farm occupation	-.24489	(-.2553)	-.00882
Mother's education	-.08720	(-.4581)	-.01889
Program contact	-4.43300	(-4.0693)*	-.01887
Constant	24.36500	(8.8842)	
Number of observations	582		
R^2	.07		
F-statistic	3.43*		

* Significant at the 5 percent level.

tings are responsive to medical advice and that education programs can affect the way parents care for their children.

Effects of malnutrition and high fertility on school performance

Both malnutrition and high fertility are found in this study to have implications for the child's ability to learn. A well-nourished child performs better in school than a malnourished one. This finding has important implications for the development of a country's human resources. If early malnutrition impairs a child's mental development, then educational resources invested in that child tend to be ineffective. Inability to take full advantage of educational opportunities, even when offered, would perpetuate the vicious circle of poverty, poor nutrition, and ill health. Improved nutrition thus would be an important complement to any program designed to raise the level of human resources.

The link between nutritional adequacy and learning ability has been the subject of much debate. Medical investigations (for example, Cravioto 1966) have shown that nutritional deprivation can limit the growth of brain cells, even while the child is in the womb. But the relationship between number of brain cells and mental ability is less certain. Winick, Rosso, and Waterlow (1970) found that children who had died of malnutrition had 15 to 40 percent fewer brain cells than well-nourished children of the same age and background who had died from accidental causes. But this does not necessarily mean that the malnourished children were less intelligent.

Several studies have investigated the relationship between test scores and nutritional adequacy. Knobloch and Pasamanick (1958) found that U.S. babies born in winter months had a lower average intelligence quotient (IQ) score, lighter body build, shorter stature, and higher incidence of mental deficiency than babies born in the spring or summer months. The cause was traced to the mother's nutrition during the critical gestation period. Another study by Willerman and Churchill (1967) compared sets of identical twins and found that in most cases the IQ of the twin with higher birth weight was about 5 percent higher at school age. Cabak and Najdanvic (1965) and Cravioto and Robles (1962) concluded that the average IQ of well-nourished children was always higher than that of the undernourished. Malnourished children, however, usually come from poverty-stricken, overcrowded homes, and multicollinearity is likely to be encountered. Important for policy purposes is a classic study by Kugelmass et al. (1944). They administered IQ tests to children over a period of time and found that the performance of malnourished children improved from 10 to 18 points after treatment. But a child receiving treatment after age 4 did not improve. If mental ability is permanently impaired by early nutritional deprivation, then it is imperative to ensure that children are well fed as early as possible. The evidence is still inconclusive, and much empirical and clinical work is needed to resolve the controversy.

A rough form of empirical testing in the present study revealed a distinct relationship between nutritional status and school grades. Even with the family's per capita income held constant, better-nourished children were found to perform better in school. To a large extent the environment was also controlled for, because in a village setting there is little difference in children's surroundings, whether the children are well nourished or malnourished. Overcrowding does not exist and the environment is generally pleasant.

Within the age range of this study (7–13) taller children in particular are the ones with better school grades (Table 18). Because height is a long-term measure of nutritional adequacy, especially in marginal cases, this finding supports the hypothesis that long-term nutritional deprivation lowers

Table 18. School performance: results of ordinary least squares regression, with grade in percentage (GRADE) as the dependent variable

Independent variable	Coefficient	*t*-ratio	Elasticity at means
Weight for age (WPTH)	-.00588	-.3273	-.00617
Height for age (HPTH)	.13049	3.1296*	.13810
Weight for height (WFH)	.02179	2.4364*	.03035
Father's occupation (OCCUF)	-.53391	-1.4390	-.00453
Sex = 1 if female (SEXF)	-.20408	-.6723	-.00114
Number of siblings under age 7 (CHLT7)	-.16137	-.9729	-.00643
Income per head (YPH)	.00002	.4339	.00030
Birth order (BTHORD)	-.25340	-2.9916*	-.00873
Father's education (EDFA)	-.11469	-1.3013	-.00536
Constant	76.73100	22.6100	
No. of observations	410		
R^2	.10		
F-statistic	4.31*		

school performance. It thus provides further support for the existence of a direct link between nutritional and mental ability. A good diet from an early age appears to be vital for proper mental development.

Children of higher birth order also tend to perform worse in school than others (Table 18). This finding is consistent with the results of other studies. For example, Record et al. (1969) investigated 50,172 children in Birmingham, Alabama, and found that children of higher birth order had lower test scores for verbal reasoning than other children. When socioeconomic class was taken into consideration, the children of higher socioeconomic status had higher scores. Nevertheless, within each class, higher-birth-order children still scored lower on the test. Blake (1981) also found that, among white couples in the United States, the more children they had, the lower the "quality"—that is, educational aspirations—of the children. These findings suggest that improved mental capacity among offspring would result from a fertility reduction program.

POLICY OPTIONS AND PROBLEMS

A dismal picture emerges from the empirical results of the current study. A large proportion of the children from low-income, low-asset farm families were found to be malnourished. Their nutritional intake was low and they were often ill. Together, poor nutrition and frequent illness limit a child's physical growth. If the child also comes from a large family, the sit-

uation is aggravated by sibling competition for family resources. If in addition the mother works outside the home, the child is further disadvantaged. Even economically better-off families have difficulty in feeding their children adequately if the mother lacks the time for childcare and access to healthcare facilities that can translate income into nutritional and health improvements for the young. Malnutrition also impairs mental development, and this does not portend well for an economically developing country.

The interrelationships revealed by the empirical analysis point to the need for development strategies that promote the multiple goals of alleviating poverty, improving nutrition and health, and lowering fertility.

The study also shows that the amount of food eaten, regardless of the kind, is an important determinant of nutritional status. Hence it supports the emerging consensus among nutritionists that nutritional deficiencies are generally the result of overall inadequacies of food intake (FAO and WHO 1976) rather than the alleged "protein gap" earlier stressed (FAO and WHO 1973).

The study further indicates that a family's overall nutritional intake is significantly increased by the value of farm production. This finding reinforces the view that agricultural development could be a critical factor in combating malnutrition. If small farm households are able to participate in the increase in productivity and income that accompanies agricultural development, then food consumption and nutritional status are likely to improve. Agricultural development is a time-consuming process, however, and there is naturally a concern for implementing more effective short-run remedies.

Intervention can be directed into three main channels: increasing income, lowering the relative price of food, and effecting changes in parental preferences and technology so that child nutrition and health may be improved.

Income-augmenting programs include direct cash transfers to needy households and the creation of remunerative jobs. The findings indicate that higher income can improve a family's nutrition and also reduce the dependency of parents on children as productive units. A decline in children's productive value is likely to lower fertility and thus reduce sibling competition.

The findings indicate that rather substantial increases in income are required to bring about a perceptible improvement in child nutrition. From reduced form estimates of the equation system (not shown), it is clear that a family would have to increase its farm income per capita by 1,000 baht per year, or by 10 percent of the mean, to raise children's average weight and height scores by a mere percentage point. A *doubling* of income per

capita would be required to lift a child from a state of third-degree malnutrition to nutritional adequacy. These very substantial increases are not likely to be brought about by ad hoc employment creation, and if such jobs draw women away from the home the consequences could be that much worse.

Transfer payments are also problematic. Not only are they likely to be politically unfeasible, but also the strain they impose on a country's fiscal machinery is likely to be considerable. The usual argument in favor of income transfers (as opposed to subsidies in kind) is probably not appropriate in the case of food consumption. If people derive benefit from seeing that other people (such as children) are adequately fed, then substantial externalities, or spillovers, are generated by food consumption. Even though income transfers may mean greater satisfaction to the recipient than in-kind transfers because he has control over expenditure patterns, they may not lead to a higher level of welfare for society as a whole. In addition, households may not possess adequate knowledge of proper food consumption. If that is the case, then in-kind transfers may be more justifiable because they generate external benefits.

Programs designed to lower the price of food in relation to other goods include taxes and subsidies, ration shops, on-site feeding, and food stamps. The issue is one of weighing the relative merits of price controls versus direct food programs. In Thailand a tax imposed on the export of rice (known as the infamous "rice premium") has as one of its main objectives the maintenance of a lower domestic price. Such a policy needs to be accompanied by price supports to prevent distortionary effects from harming the production sector. Production subsidies to small, subsistence farmers may also be required in the form of irrigation systems, agricultural credit, and fertilizer. The administrative costs of such support have to be considered, and the effect of the programs on child nutrition is uncertain.

Direct food transfers may be more timely than price interventions and politically more acceptable than cash transfers. Moreover, they can be readily designed to benefit the target groups. But their effectiveness depends on several factors. Two issues in particular are involved here: market separation, and substitution of subsidized food for private purchases.

If the market is efficient, food transfers may simply increase supply and drive down food prices, without affecting total food consumption. The success of a program depends essentially on the households' response and the constraints on their behavior. If households receive food transfers in excess of what they are prepared to consume, they may exchange the food for cash unless there is market separation (that is, restriction on resale). Converting in-kind transfers into income allows households to regain control over their pattern of consumption, and in most cases this is the path

that maximizes their utility. If resale takes place, then the effect of the food program is equivalent to an income transfer. Even without resale, the program operates like an income transfer if the free or subsidized food is less than the amount previously consumed. As the subsidy replaces household purchases, income equal to the value of the subsidy is released for other purposes. The effect of such programs on child nutrition therefore depends on the income elasticity of nutrient intake and health care for the young. For a food transfer program to be effective, the food must be offered at reduced prices and in quantities larger than what the household originally consumed. Moreover, the resale of food must be prohibited.

To ensure that children's consumption is increased, many developing countries have set up on-site feeding programs for children. Weaning foods or school lunches are fed directly to the children. This strategy effectively "separates the market" because resale is impossible. If the amount of food consumed on site is less than the amount previously consumed by the child at home, however, the effect cannot be greater than an equivalent income transfer. The food consumed on site partly replaces the food eaten at home and the marginal rates of substitution in consumption remain unchanged. Increased intake of subsidized food can be offset by a reduction in the intake of other foods purchased by the family.[5] Thus the effect on the child is uncertain because on-site feeding may occasion the withdrawal of other food from the child at home.

Nevertheless, the present study suggests that child-feeding programs could lead to some improvement in children's nutritional status. Sibling competition for food was found to be an important constraint on child nutrition, and there was evidence that mothers working in the formal sector may neglect their young children. Both competition and neglect can be counteracted to some extent by direct feeding.

The net effect of subsidizing a particular food depends on both the strength of food substitution in the home and the difference in caloric content between the subsidized food and the food that is being substituted for. It is necessary, therefore, to improve parents' education and awareness (the taste and technology variables) at the same time, to avoid adverse effects.

5. Empirical investigation of this problem has been scanty. Studies of such substitution between subsidized food and other food have tended to be ad hoc rather than analytical (for example, reports presented in U.S. Congressional hearings). Nevertheless, a study by Clarkson (1976) of the welfare benefits of the food stamp program in the United States suggests that the program has not improved nutrition among the poor. Peltzman (1973) examined a similar case of in-kind subsidies for higher education and found that where, by accepting the subsidy, the individual incurs substantial costs, the subsidy-in-kind may actually reduce total consumption.

A mother's taste and home technology can be influenced mainly through education. The immediate options include mass media advertising, door-to-door visits, food demonstrations, and improvements in the healthcare and family planning network. Many developing countries are currently undertaking these measures in an effort to improve the efficiency of childcare in rural areas. But it is important for such programs to take into account the realities of the women's situations; otherwise, the programs are doomed to failure from the start. As Levinson (1972:78) put it,

> The annals of well-meaning educators are filled with episodes of neatly arranged demonstrations attended only by the well-to-do. The educators track down the lower income mother and deliver their message to a nodding, acquiescent woman who then totally ignores it. The educator throws up her hands in horror and stomps away to write another report about the ignorant villager.

For a low-income mother, her difficult role as childbearer and rearer, food producer and processor, and household manager rarely allows her the luxury of attending a demonstration or a visit to a health clinic. Even if she attends a demonstration, she is not likely to understand the message. And even if she learns what foods are best, she may lack sufficient control over the production resources to determine which foodstuffs the family cultivates. More nutritious ways of preparing foods are often more time-consuming than traditional methods. In many cases mothers simply lack the time and resources to tend to their children's needs. Where a mother works outside the home, her child is likely to spend much of the day in the care of an older sibling. Merely providing education to women in such circumstances would not be beneficial without substantial increases in their families' income.

Another point of intervention is in health care. This study found health to be a major determinant of a child's nutritional status. Health improvements are thus essential for the effective utilization of any food consumed. Programs that reach out to the villagers in their homes are likely to be effective in improving childcare, and, if so, healthcare improvements need to be integrated into the traditional village healthcare network.

Personal contact and informal communication during the course of the survey yielded further unquantified information. For example, I found that rural women tended to use home remedies to treat their families' health problems. Occasionally they would elicit the help of some local practitioner or respected older woman if conditions appeared to be serious. Thus the health of poor rural people is not likely to be improved substantially merely by increasing the number of physicians and hospital beds or by constructing sophisticated modern facilities. Such facilities are too imposing for villagers, who are likely to prefer health services that fit into the overall patterns

of their lives. The introduction of modern facilities should be encouraged only if their superiority is clearly demonstrated. Otherwise, for village families to go outside the community to some unknown professional practitioner or service entails substantial costs. Distance alone imposes economic and social costs. Added to this, the disrespect with which they are often treated acts as a further deterrent. Only if efforts are made to reduce the economic and psychological costs of using modern health facilities and to increase the benefits such facilities can provide will rural women be encouraged to bring their children there.

A more practical approach to improving health care among poor, rural households is to improve the training of traditional healthcare practitioners. Training rural midwives in modern medical techniques is one example. The family planning efforts in Thailand are another. With lower fertility, not only would sibling competition in the home be eased, leading to better nutrition, but children's performance at school would also be likely to improve. A high birth order appears to have an additional independent effect in lowering school grades. If the effect is widespread, then reduced fertility can directly increase a country's human capital and alleviate the maldistribution of income.

CONCLUSION

Malnutrition looms large as a problem with no easy solutions. One of the main objectives of the study was to increase understanding of the economic constraints faced by rural households and the extent to which those constraints affect the nutritional status of young children. The study found that child nutrition can be improved only by substantial changes on all fronts—increased income, education, and access to health care. Because small changes are ineffective and large changes difficult to realize, the problem is that much more urgent and timely intervention is that much more necessary.

Nutritional adequacy can be viewed as a form of human capital. But unlike other types of investment in human capital, the timing of investment in nutrition is vital. Early deprivation cannot be compensated for in the way that on-the-job training can compensate for deficiencies in formal schooling. Neither can children invest in themselves at an early age through loans from, say, the capital market. This study found that better-nourished children perform better than malnourished children in school. Therefore, if a large portion of a country's population is malnourished, the signs are ominous. Given the likelihood that mental development is impaired by malnutrition, it is imperative that children be provided with adequate nutrition as early in their lives as possible.

APPENDIX A. DETERMINATION OF DIETARY ADEQUACY

Adequacy of food intake can be defined as a satisfactory balance between nutrient availability and bodily needs. Human beings require nutrients and energy food for bodily functions and the metabolic reactions that sustain life. Since most living organisms, including human beings, do not possess the biochemical machinery to manufacture all their nutritional requirements, they must obtain them from the environment (Scrimshaw, Gordon, and Taylor 1968). A low nutrient intake, insufficient to meet normal needs, effects changes within cells and tissues that act to conserve the limited supply. Deficiency diseases develop, and if the diet remains inadequate, disability and death can result. Energy foods, measured in kilocalories (or, as is now more common, in kilojoules), are needed for undertaking physical activity. An important factor here is that energy use must be synchronized with energy availability; otherwise, energy will be extracted from, or in the case of excess, stored in, the body. Because energy needs supersede all other needs, the body can be receiving sufficient amounts of say, protein but use it for energy purposes if calories are not in adequate supply.

Calorie requirements have been calculated by the United Nations Food and Agriculture Organization (FAO 1957, 1970; FAO and WHO 1973) and periodically evaluated and revised by expert groups. Difficulties arise, however, mainly because physical fitness cannot be precisely defined even within an age–sex group. Dietary requirements vary widely from individual to individual for various reasons.

One of the most crucial caloric variables is the level of physical activity. FAO's standards provide useful caloric adjustments for differences in age, sex, body size, and environment, but the effect of alternative levels of physical exertion is difficult to allow for adequately. Only for the very young would this not cause a serious problem.

Devices invented to measure human energy output have established that a moderately active person uses 25 percent of available energy for physical activity and 50 percent for basic metabolism. Thus muscular exertion is the second largest user of calories (Swift and Fisher 1964). Human activity can vary greatly, however. Caloric costs have been calculated for various organized sports and occupations (Durnin and Passmore 1967), but those findings are mostly inapplicable to peasant societies, in which work periods and levels of exertion, even for children, can fluctuate widely from day to day and also with the agricultural cycle (Beeghly 1972).

Two measurement processes have evolved whereby the activities of specific individuals can be monitored and energy output studied. Those processes are calorimetry and measurement of the heart rate. Calorimetry, the process of measuring heat, can be done directly or indirectly because a significant relationship exists between oxygen intake and heat output dur-

ing the process of metabolism (Durnin and Passmore 1967). Food enters the body as stored energy; to fuel bodily functions, it must be liberated by oxygen through the process of oxidation. Once released, energy facilitates chemical synthesis, muscular work, and ionic balance. Ultimately, it is reduced to heat. Thus metabolic activity can be determined either directly, through the output of heat, or indirectly, through the intake of oxygen. The heart rate can be used as a measure of energy output because a linear relationship exists between it and an individual's oxygen uptake over most of his range of activities (Wyndham et al. 1959; Malhotra et al. 1963; Ekblom 1969). A complication arises, however, when greater cardiac capacity occurs in response to physical exertion so as to produce a lowered heart rate. Both calorimetry and heart-rate measurement require sophisticated equipment and body attachments to ensure accuracy and effectiveness, and this makes their use cumbersome and impractical.

Even if activities are the same, there is no simple relationship between food intake and task performance. One factor that must be considered is disease, which can affect the requirements for nutrients in many ways. Chronic infections can cause a slowdown in the gastrointestinal function and increase the need for dietary protein; acute infections can result in losses of nitrogen, vitamins, and minerals; parasitic infections can prevent proper nutrient absorption; disease may upset the mechanisms that control the metabolism of essential nutrients; acute and chronic infections can adversely affect absorption of nutrients in the digestive tract; and trauma and stress, which often accompany disease, can alter the body's protein requirements (Scrimshaw, Gordon, and Taylor 1968). The amount of food regarded as necessary therefore varies with the incidence of disease.

Diet itself affects nutritional requirements in several ways. The form of a nutrient may affect the degree of absorption and utilization by the body. For example, iron from vegetables is less readily absorbed than iron from meat. Variability in nutrient form and eating habits on a seasonal or annual basis may affect nutritional requirements. Composition of the diet also affects the body's utilization of nutrients. For example, it is believed that each of the essential amino acids must be simultaneously present for protein synthesis to proceed. Finally, certain vitamins are produced by bacteria that live in the small intestine in a symbiotic, or mutually beneficial, relationship with the host. These vary from individual to individual.

Dietary requirements are necessarily affected by the physical and socioeconomic environment, including climate, type of clothing, sanitary conditions, hygiene, eating habits, and the ability to maintain hygenic standards.

Disease, dietary factors, and the environment in combination make recommendations of dietary adequacy extremely difficult, and therefore only guidelines can be set. Recommended daily allowances set by international

agencies are usually based on Western meat-based diets and do not adequately take into account cultural variations in diet or the other factors that affect nutritional adequacy.

APPENDIX B. QUESTIONNAIRE DESIGN

The questionnaire contained eight sections: basic information on household numbers; income and wealth; major expenditures and investments; marriage and reproductive history; childcare and mother's knowledge and beliefs; household food consumption patterns; children's nutritional status and disease history; and children's school performance.

1. Basic information on household members

Household members were defined as related persons who pooled their earnings and had common arrangements for housekeeping, finance, and the provision of food and other essentials. Membership was determined on a de facto basis, and household members absent for less than one month were counted. Name, age, sex, educational attainment, relationship to household head, and main economic activity were recorded.

2. Income, earning activities, and wealth

Total household income was calculated for the calendar year immediately preceding the survey.[6] It included wages and salaries; property income such as land rent and interest; transfer payments received such as assistance payments; the value of goods and services received as part of pay, the value of unpaid farm help, and the value of goods and services produced in the home and consumed, or received free of charge from other sources; net profits from family enterprises; income from livestock and occasional activities such as fishing; rental value of owner-occupied dwellings; and other monetary receipts such as gifts from nonmembers of the household and lottery winnings.

Detailed information was obtained on land ownership and cultivation, use of farm equipment, number of employees, and animals owned. A checklist was used to facilitate an inventory of consumer durables in the household's possession. Items on the list included clock, iron, electric fan, radio, sewing machine, bicycle, motorcyle, refrigerator, television set, and stereo. Housing quality, represented by the size of the house, the type of windows, roofing, flooring, and building materials, were noted from observation.

3. Major expenditures, investments, and debts

Respondents were asked about outlays for major items, such as purchases of gold, land, and machinery, and about investments and sources of funding. Other questions inquired about outstanding debts, the interest rate

6. The pretests were done in December 1979 and the actual survey administered in January 1980. Since the harvest occurred in December, the main economic activity of the year had just been completed.

paid, the lending source, and the purposes for which loans were incurred during the past calendar year.

4. Marriage, fertility, and use of contraception

Information was obtained about female respondents' age at first marriage and at subsequent marriages, if any; ideal and expected family size at time of marriage and at the time of the interview; pregnancies, including the outcome of each and type of prenatal care received; and use of contraception, duration and methods used, and, for women who had stopped using contraception, their reasons for stopping.

All of the data except for the pregnancy history were obtained from fixed-option questions. For the pregnancy history a matrix format was used that was based on the life-history matrix utilized by Lauro (1977); but because it was confined to a single event (pregnancy), its use was facilitated and the probability of omitting incidents was greatly reduced. The age-by-variable matrix helped respondents to recall events they had experienced at each age and provided a convenient means for cross-checking the data.

Obtaining accurate information about respondents' desired fertility posed several problems. Parents might rationalize unplanned births by regarding them as desired after the fact. The alternative to asking about desired number of children was to use actual fertility as a proxy for desired fertility, but this also has problems. A large proportion of the women in the sample (whose ages ranged from 15 to 57) would not have completed their fertility at the time of the survey. Moreover, the sample was limited to women with at least one child less than 7 years old, which meant that a disproportionate number of women were in the younger age groups. The actual fertility experience of young women is not a reliable indicator of their completed fertility. And if unplanned births are common, actual fertility will be a poor proxy for desired fertility. Therefore no attempt was made to ascertain respondents' desired number of children. In this study, fertility is represented by the number of births respondents had had per year of cohabitation during the previous seven years. Although this item established recent rather than total fertility, it ensured that the births being identified and the variables explaining them were measured within the same time period, in contrast to cross-sectional studies of completed fertility. In addition, the number of children under age 7 was likely to be more important than the total number of births in affecting the nutritional status of children under age 7. Another reason for focusing on recent fertility was that older children may substitute for a mother's time in caring for younger siblings and therefore would not enter into the quality-quantity tradeoff postulated here.

5. Childcare and mothers' knowledge, beliefs, and aspirations

Mothers were asked whether they had breastfed their children and for how long, when they had introduced their children to solid foods, and generally which kind of infant care they had provided. Mothers were also asked about their beliefs, superstitions, and reactions to illness. Other questions were whether they knew of any modern contraceptive method, whether they were aware of the health benefits of breastfeeding, and whether they believed in supernatural methods of healing. To gauge parental attitudes toward hygiene and health care, respondents were asked whether they had received any modern prenatal care during the last pregnancy and whether modern medical attention would be sought as a first choice in times of illness. They were also asked whether they considered education to be necessary for their children and, if so, how many years of education they regarded as essential for their children to earn a "good" living.

6. Food consumption and intrahousehold division of food

Food consumption by the family was calculated as consumption per adult equivalent over a period of six months. To determine the total quantities of different foods consumed, respondents were asked about the quantities of each food item consumed and the frequency of consumption. The unit of measurement was not determined in advance, and responses were recorded according to whatever unit of measurement was meaningful to the respondent. If necessary, a follow-up question was asked about the average quantity consumed per meal. Because the villagers had very similar diets, it was possible to draw up a list that included virtually all the food items.

Respondents were asked about total quantities consumed by the family because I believed this to be easier for them to recall than the amount consumed by each household member over a twenty-four-hour period. Not only is the accuracy of recall a problem for rural respondents, but also the manner in which food is consumed. Where family members take their share of food from several common bowls, a precise assessment of the amount eaten by each person may be impossible. The responses obtained were subsequently rescaled on a six-month basis and valued at prevailing prices. Separate schedules were drawn up for the wet and dry seasons, and a simple average taken for valuation purposes. Attempts were also made to determine the distribution of food among household members, but I believe the responses are unreliable. The figures obtained were compared with data from a survey conducted in the same area by the Institute of Nutrition and the Ministry of Agriculture (undated and untitled worksheets). The mean values proved not to be significantly different from each other at the 5 percent level.

The questionnaire elicited information on the number of months children were breastfed and the customary weaning period. Whether a particular child was in the weaning period was also noted. Two alternative meanings of weaning exist in the literature: the cessation of breastfeeding, and the time at which solid foods or foods other than milk are introduced. Health risks of weaning arise because supplemental food may be inadequate or unhygienically prepared. I therefore adopted the definition of weaning as the period commencing when solid foods are introduced and continued until three months after suckling has been discontinued (Scrimshaw, Gordon, and Taylor 1968).

7. Height and weight measurement of eligible children and recording of their disease history

The weighing and measurement of each child was undertaken by two trained prenurses, and I did spot-checking for possible error. The weight and height measures were then calculated as percentages of the standards for healthy Thai children. The standards for children up to 6 years of age are the fiftieth percentile of the weights and heights of 2,520 well-nourished Bangkok children, documented by Khanjanasthiti (1977).

Respondents were also asked about each child's disease history. Recorded information included frequency of diarrhea, fever, and incidence of such diseases as typhoid, diphtheria, and tuberculosis. Three separate measures of infection and disease were defined: whether the child had continuous diarrhea for more than four days during the month prior to the survey; whether the child had a fever for more than four days during that period; and whether the child had ever suffered from a serious illness such as tuberculosis, typhoid, or diphtheria. A single cross-sectional survey precludes a reliable reconstruction of a child's medical history because recall inaccuracy is likely to be high. Moreover, responses contain a large element of subjectivity and depend a great deal not only on parental recall, but also on the respondents' perception of what constitutes a health abnormality. Such lack of refinement in measuring a child's health weakens the explanatory power of the model, but the incidence of disease reflects the composite effect of other underlying health problems and is therefore appropriate if a single measure of health has to be selected.

8. Teacher interview and recording of nutritional status and school grades

Older siblings attending primary school were weighed and measured. The anthropometric standards found in Chavalittamrong and Vathanakanon (1978) were used as the standards for the school-aged children. Teachers were asked about children's overall performance and health, and each stu-

dent's grade and record of absence from school were obtained from the teacher's records.

The interview schedule was made as simple as possible. It was composed mainly of fixed-option questions. The main part of the questionnaire (through section 7) required an average of one hour and fifteen minutes to complete. The principal problem respondents had was in recalling their full pregnancy histories (section 4). Recalling the quantity and frequency of each kind of food consumed (section 7) also presented problems, but interviewers made extensive probes and the results are believed to be satisfactory.

Appendix Table 1. Household model variables

Variable (mean, S.D.)	Description
ENDOGENOUS VARIABLES	
Nutritional status	
Average weight (91.97, 9.85)	Average weight of all children in the household, each weight being a percentage of the reference weight for children of that age and sex
Average height (94.03, 4.56)	Average height for all children in the household, each height being a percentage of the reference height for children of that age and sex
Average weight for height (103.66, 13.56)	Average weight of all children in the household, each weight being a percentage of the reference weight for children of that height
Child mortality (.108, .258)	Deaths to children under age 7 as a proportion of total births within the last seven years
Fertility (.473, .233)	Number of live births per year of exposure to conception in the last seven years
Formal-sector work (22.89, 16.01)	Average weekly hours spent by the mother in formal-sector work
Informal-sector work (.482, .250)	Dummy variable = 1 if the mother engages in informal-sector activity compatible with childcare
Food expenditures (276.09, 83.65)	Value of household food consumption per adult equivalent per month
EXOGENOUS VARIABLES	
Mother's age	Mother's age in years
Childbearing < 20 (.267, .453)	Dummy variable = 1 if the mother was less than 20 years old when she bore her first child
Childbearing > 35 (.100, .300)	Dummy variable = 1 if the mother was more than 35 years old when she bore her first child
Excess number of children (-.278, 1.39)	Number of children stipulated by the parents as being in excess of the desired number
Number of young children (2.43, 1.18)	Number of children less than 7 years old in the household
Mother's education (4.02, 1.26)	Education of the mother, in years of completed schooling

Appendix Table 1. (*continued*)

Variable (mean, S.D.)	Description
Ignorance variable 1 (.112, .315)	Dummy variable = 1 if the mother does not know of at least one modern method of birth control
Ignorance variable 2 (.331, .471)	Dummy variable = 1 if the mother believes in supernatural methods of healing
Ignorance variable 3 (.605, .489)	Dummy variable = 1 if the mother expresses ignorance about proper breastfeeding and child-care practices
Prenatal care (.134, .341)	Dummy variable = 1 if the mother received modern prenatal care during her last pregnancy
Program contact (.735, .442)	Dummy variable = 1 if the village has had contact with a health program
Abnormal pregnancy (.072, .197)	Number of pregnancies terminated "abnormally" (stillbirths, spontaneous abortions, and induced abortions), as a proportion of the total number of pregnancies
Total income (17659, 10711)	Household income other than the mother's earnings in informal-sector employment, if any
Income per head (4980.78, 1398.20)	Household income per head other than the mother's earnings in formal-sector employment
Farm income (11043, 8357)	Value of farm production during the preceding year
Nonfarm income (6616, 6142)	Value of nonfarm income during the preceding year
Mother's wages (59.68, 18.91)	Mother's average formal-sector weekly wage rate
Wealth Index 1 (.034, .844)	First factor resulting from the principal components method of data reduction: an index of high-priced consumer durables owned
Wealth Index 2 (.040, .824)	Second factor; an index of lighting equipment owned
Wealth Index 3 (.020, .719)	Third factor; an index of building materials used
Wealth Index 4 (.276, .597)	Fourth factor; an index of nonessential consumer durables owned

Appendix Table 1. (*continued*)

Variable (mean, S.D.)	Description
Wealth Index 5 (.005, .457)	Fifth factor; an index of small consumer durables owned
Planted area (71.39, 2110)	Total number of *rai* under cultivation in the preceding year
Childcare alternatives (.543, .499)	Dummy = 1 if older relatives are present in the household and provide childcare
Priority given to children (.483, .500)	Dummy = 1 if children are given priority in food consumption
Farm occupation (.723, .448)	Dummy = 1 if the father's primary occupation is agriculture
Father's education (4.34, 2.01)	Number of years of schooling completed by the father

Appendix Table 2. Child model variables

Variable (mean, S.D.)	Description
ENDOGENOUS VARIABLES	
Nutritional status	
Weight (91.04, 11.28)	Weight of the child as a percentage of the reference weight, using Thai anthropometric standards for children of that age and sex
Height (93.54, 6.11)	Height of the child as a percentage of the reference height, using Thai anthropometric standards for children of that age and sex
Weight for height (99.39, 13.68)	Weight of the child as a percentage of the reference weight for children of that height
Child health	
Diarrhea (.032, .176)	Dummy variable = 1 if the child had more than four continuous days of diarrhea during the month immediately preceding the survey
Fever (.061, .239)	Dummy variable = 1 if the child had more than four continuous days of fever during the month immediately preceding the survey

Appendix Table 2. (*continued*)

Variable (mean, S.D.)	Description
Disease (.198, .399)	Dummy variable = 1 if the child suffered from chronic typhoid or tuberculosis
Child mortality	(Same as in the household model)
Fertility	(Same as in the household model)
EXOGENOUS VARIABLES	
Space before (9.77, 11.81)	Interval in months between this birth and the following pregnancy (= 18 if this is last birth)
Space after (21.64, 22.04)	Interval in months between the beginning of this pregnancy and the preceding birth (= 18 if this birth is the first birth)
Pregnancy order (3.75, 2.78)	Dummy variable = 1 if the child's pregnancy order is greater than 4
Breastfeeding (1.44, 2.12)	Proportion of the child's life during which child is breastfed
	If age $<$ 24 months, proportion = (# months breastfed)/age
	If age $\geq$ 24 months, proportion = (# months breastfed)/24
Weaning (.503, .500)	Dummy variable = 1 if the child is in the weaning period
Birth order (3.38, 2.26)	Birth order
Female (.497, .500)	Dummy variable = 1 if the child is female

Note: The means and standard variations are for the total sample of 1,006 preschool children only.

Appendix Table 3. Consumer durables used to construct the wealth indexes, by factor loading resulting from varimax rotation

Consumer durable	FACT1	FACT2	FACT3	FACT4	FACT5
Electricity	.1333	.8726	.1346	.2198	.1706
Fan	.2793	.1794	.1149	.8608	.1041
Refrigerator	.7700	.1005	.0761	.0230	.1019
Iron	.4079	.3006	.0892	.5225	.1512
Rice cooker	.2129	.1048	.0386	.3747	.0247
Radio	.0107	-.0062	.0258	-.0072	.4844
Clock	.1301	.1146	.1433	.0963	.5050
Sewing machine	.3632	.0606	.2620	.1371	.2192
Bicycle	.0837	.1126	.1711	.0633	.3522
Motorcycle	.3099	.0966	.1705	.1193	.1746
Television	.6684	.0300	.0781	.1518	.0721
Car	.3656	0715	0838	1453	0289
Lighting	.1125	.8796	.1458	.1867	.0980
Building material	.1777	.1115	.7531	-.0017	.0619
Window	.0830	.0934	.4701	.1400	.2305
Flooring	.4430	-.0074	.4542	.0426	-.0632
Size of house	.0051	.0825	.4366	.0498	.2597
Eigen value	4.15955	1.24659	1.04740	0.56671	0.44275
% variance	55.7	16.7	14.0	7.6	5.9
Cum %	55.7	72.4	86.5	94.1	100.0[a]

Note: Selection of items was based on a loading that was rounded to at least 0.5.

a. Rounded total.

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